ELEMENTARY SCIENCE LESSONS

STANDARD I.

ELEMENTARY SCIENCE LESSONS

BEING A SYSTEMATIC COURSE OF

PRACTICAL OBJECT LESSONS

ILLUSTRATED BY SIMPLE EXPERIMENTS

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STANDARD I.

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PREFACE

THE present volume consists essentially of a systematic course of Practical Object Lessons, designed and arranged specially for the purpose of developing and training the minds of young children. As such it might stand by itself, or be combined with any other course of lessons, being general and fundamental in its character.

It forms the first year's course of a system of Elementary Science Lessons (such as those contemplated by the Revised New Code), which will carry the children step by step from the preliminary and general training of the lower standards to the more specialised science lessons for older scholars.

The present course is on much the same lines as the author's 'Object Lessons for Infants,' first and second series (Longmans), and may with great advantage be preceded by those two series of lessons.

The author can speak from a long experience of science teaching in elementary schools as to the educational value of practical object lessons, with simple ex-

perimental illustrations of the character of those sketched out in the following pages, in cultivating the intelligence of the children.

The scheme, of which the present course forms a part, was drawn up at the request of the Liverpool School Board to meet a long-felt necessity for a continuous and connected system of practical object lessons running throughout the whole of the elementary school course and developing into the more specific experimental science teaching of the higher standards.

W. H.

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INTRODUCTION

SUGGESTIONS TO THE TEACHER

In the earlier years of life the education should be, for the most part, directed to the right development and training of the various faculties of the child and to the formation of good habits. The educator should aim at promoting and directing the growth of the mental powers, at developing the activities of the mind and directing them into right channels, and at the formation of habits of careful observation, clear reasoning, and exact statement.

The success of the child in later years in acquiring, assimilating, and utilising information will depend in a very large degree upon the manner and extent of this preliminary training. The accumulation of useful knowledge at this period of life, while unquestionably valuable and indeed necessary, is still, however, to be regarded by the teacher as subordinate to the much more important function of the development and training of the mind; in other words, *instruction* must be subordinated to *education*. And it is therefore necessary that we should, in our system of education, include those subjects and adopt those methods which experience and reason alike indicate as leading most directly and successfully to the end we have in view.

It is now very generally recognised that properly arranged object lessons—that is, lessons treating of concrete things or of phenomena which may form the subject of direct and personal observation on the part of the chil-

dren—furnish better opportunities for this cultivation of the general intelligence than perhaps any other kind of lesson. The object lesson may, however, be considered as having two more or less distinct functions—first to impart useful information about certain objects or phenomena which it is desirable that the children should possess; and secondly to exercise the children in observing and recognising certain important facts or principles in connection with the objects or phenomena, in reasoning about those facts or principles, and in stating in clear and precise language the ideas which they have formed as the result of such observation or reasoning. It depends on the age and previous education of the children, and on other circumstances, whether we should regard one of these functions as of more importance than the other; but as to which function should receive first consideration in early education there can scarcely be any question.

It is the latter of these two functions which is most consistently and extensively developed in the following lessons. A series of more or less connected common objects and phenomena are taken as the materials upon and about which the children are invited to exercise their powers of observation and reasoning. The teacher, and when possible the children themselves, are directed to perform certain very simple operations or experiments, in order to increase the otherwise somewhat limited field for observation, or to test the correctness of certain conclusions.

The amount of actual useful information contained in each lesson is as a rule very small, and could be *told* to the class in a very few sentences with little trouble, but probably with as little benefit. The children, however, are to be told nothing which they may reasonably be

expected to find out for themselves. They are rather to be brought as much as possible into the attitude of discoverers; and then the very act of discovery and of independent thought and original observation will prove beneficial out of all proportion to the practical value of the information obtained. Still it is hoped that the full scheme of Elementary Science Lessons, of which this course forms a part, will not merely train the minds of the children, but will at the same time familiarise them with those simple general principles which lie at the foundation of all that systematic and organised knowledge which is known as natural science, and with a knowledge of certain facts which may prove useful to them in after life.

The lessons are intended to be almost entirely conversational in their character, and the children are to be encouraged to state (*in complete sentences*) their ideas and their conclusions in simple but precise language. The teacher s part will be mainly that of a leader, seeking to concentrate the attention of the children and to prevent the conversation becoming desultory, suggesting lines upon which the examination of the object should proceed, assisting the children by the simple experimental illustrations, and helping them to express themselves in clear and correct language. The children are to be encouraged to observe the relationships between objects, the resemblances and contrasts; and to seek for reasons and causes which may serve to explain certain results which they have observed. Every opportunity of connecting a newly discovered fact about a particular object with something previously learnt must be taken advantage of, and the value of the lessons will thus be materially enhanced.

The order and arrangement of the lessons are the result of very careful consideration, and the relations between the lessons have been arranged with a view to their being taken systematically and in regular order. Each lesson is expected to occupy about half an hour.

The teacher is recommended to study carefully the notes suggesting the manner in which the lesson should be treated, with the objects required for the illustrations before him. The experimental illustrations are so simple in their character, and the apparatus required so common and readily obtainable, that no teacher need find any difficulty in those respects. (It has been the writer's aim to make the apparatus and experiments suggested as simple as possible, knowing as he does from experience that there is then the less danger of the children missing the point which it is the object of the experiment to illustrate.) But, however simple the lesson and the illustrations may appear, they are in their substance and arrangement the outcome of much thought and care; and no conscientious teacher would think of giving any of the lessons without having previously mastered the general plan and substance of the lesson and the principle which it is designed to illustrate. It will only be when this preparation has been carefully made that the teacher will be able to make the most of the lesson, and to lead the children on step by step in accordance with an orderly arrangement present in his own mind. To aid in this an analysis of each lesson is given, which may serve as notes to be used at the time of delivery. It may, however, again be pointed out that these notes are not to suggest to the teacher matter which he is to communicate to the children, but rather the portion which is next to be the subject of conversation, and about which he is to lead the children to *give* information as the result of thought or observation.

LESSON I.

A SHEET OF GLASS.

OBJECTS REQUIRED—*Sheet of ordinary window glass; burning candle in candlestick; glass bottle or tumbler.*

ANALYSIS OF LESSON.

Children recognise glass—use in windows.

Illustrate transparency.

Exps.—*Look through; place candle behind; let sun or burning candle shine through on to book.*

Children touch glass and ascertain that it is smooth and hard.

Note bright appearance.

Note shape of piece,—will not readily stand up,—must lean against some support or lie flat; call it *sheet.*

Bottle or tumbler is of similar substance, but different shape.

Exps.—*Put pencil inside; let light shine through.*

Mention briefly bending and shaping of glass when very hot or after melting.

Point out sharp edges and still sharper corners of sheet where cut or broken.

Glass easily broken by fall, blow, &c.; said to be *brittle.*

NOTES.

Subject of Lesson.—Familiar substances are recognised by certain characters (or properties) which we learn to associate with them, and which are usually independent of the form of the particular portion of substance under observation.

Let children name the substance (glass) shown them, and point out similar pieces in the windows. Illustrate its suitability for windows by showing that light passes readily through it, and objects can be seen distinctly through it.

The hard, smooth surface of ordinary pieces of glass when touched, and the bright surface apparent to the sight when the glass is clean, are also familiar characters.

The large flat piece which will not readily stand up without being supported by the hand, or resting against a wall, &c., is not characteristic of glass, but of similarly-shaped pieces—which may be called *sheets*—of any substance.

The bottle or tumbler is very different in shape and will stand upright alone; but it is hard, smooth, bright, and transparent like the glass sheet and agrees with it in many other ways, and so is said to be of the same substance. A little description of the softening and even melting of glass by great heat might be given, to explain how the substance may be worked into any shape.

The sheet has edges which are sharp and likely to cut the fingers, and corners which are still sharper, especially on broken pieces of glass.

The brittleness of glass is an important character,

and children may be led to speak of several ways in which pieces of glass are readily broken: e.g. by a fall, a blow from a stick or stone, &c. If necessary a small piece might be thus broken and the very sharp edges and points noted.

LESSON II.

A SLATE.

OBJECTS REQUIRED—*School slate (unframed); burning candle; slate pencil; pocket knife; sheet of glass.*

ANALYSIS OF LESSON.

Slate will not stand up alone—will lie flat; get name *sheet.*

Why not call it glass? Note such differences as following:—

1. Not transparent.

   Exps.—*Show it stopping light of sun or candle and causing shadow; hide object behind it.*

2. Rougher to touch.

   Exps.—*Touch glass and then slate; rub pencil on each.*

3. Not so hard.

   Exp.—*Scratch slate with point of knife; draw knife across glass.*

Slate does not let water soak through it.

Exp.—*Pour water on slate laid horizontally; incline slate, and water runs off at lower side.*

Flat sheets of slate useful for roofing buildings. Why?

Slate not made by man, like glass, but is found naturally and split into sheets.

NOTES.

Subject of Lesson.—Another substance may have the same external form as the glass sheet, and yet because of a difference in important properties is said to be a different substance. The common flat pieces of slate have characters very different from those of glass, which render them suitable for other and distinct purposes.

Show that the piece of slate will lie flat but not stand alone, and therefore in so far resembles the sheet of glass.

But this resemblance is only in shape; it differs from glass in several important characters.

1. It does not let light pass through, but stops the light and causes dark patches called shadows, and therefore would be unsuitable for windows, &c.

2. It has not the same bright, smooth surface, but feels distinctly rough to the touch. This character renders it suitable for writing upon with a pencil, which merely slides over the smooth glass, leaving no mark.

3. It is not so hard but that many things rubbing against it may easily scratch it. Refer to the lines scratched by knives on slates as guides in writing, drawing, &c. Also speak of the necessity for care in using slates to prevent scratches.

Sheets of slate are used for roofing purposes, because they are readily obtained, light, and do not let water run through them. Show water lying on horizontal surface of slate, and running downwards over surface of slate when inclined. Briefly illustrate the arrangement of slates on the roof of a house.

Glass has to be made by man, but slate is a natural substance, occurring abundantly as a kind of rock in hilly districts. It has a great advantage over most rocks in that it may readily be split into suitable thin, flat pieces.

LESSON III.

A SMALL WOODEN BOARD.

OBJECTS REQUIRED—*Flat piece of wood (clean and unvarnished piece of deal board); sheet of glass; slate; knife; slate pencil.*

ANALYSIS OF LESSON.

Recognise form as similar to glass and slate in preceding lessons.

Why not call the substance glass or slate?

Point to other pieces of wood in room and explain different appearances.

Wood is softer than slate or glass.

Exp.—*Stick point of knife into wood.*

Slate pencil scratches or grooves wood.

Exp.—*Try to write with pencil on wood.*

Wood not so brittle as slate or glass.

Exp.—*Let wood fall.*

Note 'grain' marks of wood,—direction in which best broken.

Exp.—*Split off piece with knife.*

Feeling of wood when touched very different from slate or glass.

Exp.—*Let child distinguish between them by touch alone.*

Wood is obtained from trees and readily sawn and cut into shape.

Examples of articles made of wood.

Wood very suitable for some purposes; not suitable for windows, and not so suitable as slate for roofs.

NOTES.

Subject of Lesson.—Another substance is introduced which has a similar form to the pieces of glass and slate in preceding lessons, but which is recognised as a different substance by its possessing different properties. The nature of the substance is thus again independent of its form, and its uses are also different, owing to its different characters.

Let the children recognise the piece of wood as having a similar form to the sheets of glass and slate used in the preceding lessons; also the characters due to form only: e.g. lying flat, not readily standing upright, &c.

Let them recognise the substance, give reasons for not thinking it slate or glass, and reasons for thinking it is wood.

Let them point out other articles in the room made of wood, and explain why the appearance probably differs from that of the specimen: e.g. the floor is dirty, the blackboard is painted over, the desks are varnished.

Stick the point of the knife into the wood, show with the glass and slate the impossibility of doing this, and draw the inference that wood is softer than those substances. In this connection, speak of the possibility of driving nails into wood, and thus of a simple means of fastening pieces of wood together.

Show again with the slate pencil the attempt to write on glass and on slate; then try to write on the wood with it, noting the scratch or indented mark—proving in this way also that the wood is softer.

Let the wood fall, and the children state probable effect in case of slate or glass. Strike the wood with a knife or other hard body, and describe it as not so brittle as slate or glass.

If wood is not so easily broken, how can we separate pieces from it? Let them suggest cutting with knife or saw, and point out direction in which it can be most easily cut. Split off a small piece in that direction with a knife.

The feeling when wood is touched with the hand is different from that when slate or glass is touched; let the children try and describe the difference: e.g. it is not so cold, is rougher, &c. Let them, with their eyes closed, distinguish between the bodies by the touch.

Some conversation as to the source of wood, the felling of trees and cutting up of the wood into pieces of various shapes might follow, and then examples pointed out of various articles constructed of wood.

The children might be asked to give reasons why wood is so valuable for constructive purposes (e.g. it is easily worked, readily joined, strong, abundant), and why it is unsuitable for windows and less suitable than slate for roofing purposes.

LESSON IV.

A SHEET OF PAPER.

OBJECTS REQUIRED—*Sheet of white tissue paper; sheet of white foolscap paper; wood (from last lesson); knife; scissors; slate pencil; lead pencil; piece of stout cardboard.*

ANALYSIS OF LESSON.

Sheets of paper lie flat on table, but bend when laid on hand. Why?

Exps.—*Lay paper on hand; set upright, resting against something; hold loosely by two hands.*

Cardboard, made of many pieces of paper together, does not so bend.

Exps.—*Lay cardboard on hand or hold it horizontally; split cardboard on edges.*

Advantages of yielding character of paper.

Exps.—*Roll up sheet; fold; wrap up object.*

Paper is not brittle.

Exps.—*Drop paper; strike it; fold and crease it.*

It is readily torn or cut.

Exp.—*Tear, and cut with knife and scissors.*

Readily yields to hard body.

Exp.—*Press with slate pencil on foolscap paper; draw lead pencil lightly over.*

Allows some light to pass.

Exp.—*Hold foolscap to window, then tissue paper.*

Difference in sound when wood and paper struck.

Exp.—*Strike each with pencil.*

Manufactured of fine threads.

Exp.—*Tear tissue or brown paper.*

NOTES.

Subject of Lesson.—The sheet of paper gives still another example of a body having a similar shape to those previously examined, but composed of somewhat different material and characterised by distinct properties.

The children will at once recognise the sheets of paper and note the resemblance in form to the pieces of glass, slate, and wood. Show the paper lying flat on the table. Lay it on the hand, call attention to its bending over, and ask for an explanation of this difference from what would be observed in the case of wood—it is so thin and weak. Show it standing on edge resting against some support, but with great tendency to bend; and hold it also loosely by its two ends, and again note the bending, comparing it in each case with the wood.

Take a piece of cardboard, lay it on the hand, set it upright, &c., to show its greater strength. With a knife split the edge of the cardboard, to show that it is composed of several sheets of paper fastened together, and that that explains its greater strength.

Explain that while paper is inferior to other materials where strength is required there are advantages connected with the ease with which it can be bent: e.g. a large piece can be rolled up into a small space, folded, or wrapped round other bodies.

Paper is less brittle even than wood, as shown by the fact that it may not only be dropped or struck, but may even be bent double and pressed to form a crease, without breaking.

It can, however, be readily torn or cut. Crease the paper and cut it through with a knife; also cut it with knife and scissors without first creasing.

Draw the slate pencil over the paper and note the

crease or groove made; draw the lead pencil lightly over the paper and note the mark which it leaves.

Hold the sheet of foolscap paper in bright sunlight or against the window pane, and notice that some light comes through, but not so readily as through glass, and objects are not visible through it.

Hold tissue paper up in the same way, and let the children observe the greater quantity of light passing, and give the reason.

Hold up the sheet of paper and strike it with the lead pencil; similarly strike the board and note the difference in sound; so that we might thus distinguish between them without seeing them.

Explain briefly that paper is made up of very fine threads (tear tissue or brown paper and observe the very fine threads projecting from the torn edges), obtained from rags, grass, &c.

LESSON V.

COMPARISON OF SHEETS OF PAPER, GLASS, WOOD, AND SLATE.

OBJECTS REQUIRED—*Sheets of paper, glass, wood, and slate used in preceding lessons set upright against some support; lead pencil.*

ANALYSIS OF LESSON.

Name the bodies resting upright against some object.

State some character noticeable (by sight) of each.

Strike each with pencil. Note the sound, and then let children state, without seeing, which one is struck.

Distinguish each by touch, and state the differences.

Arrange in groups on various principles and write names on board in similar groups: e.g.

(1) May be written on with lead pencil.
(2) Let light through.
(3) Will burn.
(4) Scratched by a knife.
(5) Natural or manufactured.

State of any particular group on board the principle of association.

NOTES.

Subject of Lesson.—Direct comparison of the bodies of similar form but of different substance examined in preceding lessons will serve to recapitulate points of resemblance and difference previously noted, and therefore the means of distinguishing one from another or of associating one with another.

Set up the four sheets leaning against some support (e.g. against piles of books), and let the children name them and point out some character of each which they remember noticing in a previous lesson: e.g. they can see through the glass, the slate is grey and does not shine, the paper bends, &c.

Besides the differences which may be seen there are differences to be heard. Knock each gently with the pencil and let children note the difference in sound. Then let several children state without seeing which one is struck.

Similarly there are differences perceptible to the touch, and the children should be able to distinguish and name the substances by the touch alone. Let them attempt to describe the difference they observe in each case.

Then let the children associate the bodies according to various characters common to certain of them, laying together those bodies which agree in that particular character; and the teacher should write the names on the blackboard in groups. Thus let the children lay by themselves—

1. Those which may be written on by a lead pencil, the teacher afterwards writing on the board the names of the two groups, thus:

Wood	Glass
Paper	
Slate	

Then lay all together again and in a similar way select, and afterwards write the names of—

2. Those which let light pass through.

Glass	Wood
Paper	Slate

3. Those which will burn.

4. Those which may be scratched by a knife.

5. Those which are not found naturally, but are manufactured by man.

Lastly, the teacher should point to one of the groups of names on the board and let the children state the principle of grouping in that particular case; and so with the others.

LESSON VI.

POSITION.

OBJECTS REQUIRED—*Sheets of glass, slate, and paper; tumbler; piece of chalk; lead pencil; book.*

ANALYSIS OF LESSON.

Relative position of superposed pieces of slate, paper, and glass —*on, under, between.*

Difference between *on* and *in.*

Exps.—*Place chalk* in *tumbler* on *slate; place pencil* in *tumbler and* on *tumbler, paper* in *book and* on *book.*

Difference between inverted tumbler placed *on* or *over.*

Exp.—*Tumbler inverted* on *slate* over *chalk.*

Bodies moved *from, towards,* or *round* others.

Motion *from* one body may be *towards* another.

Position with regard to a person's body—*before, behind, right-hand side, &c.*

Description of position varied by point of reference.

Exp.—*Several children describe position of same slate with reference to themselves.*

Position of slate with reference to desk or table.

Exp.—*Child lay slate in given position relative to table.*

NOTES.

Subject of Lesson.—The position of one body with reference to another has frequently to be observed and described, in addition to the nature of the substance and the form of the body. This lesson is an exercise on such observation and description.

Let the children name the objects. Then explain that in this lesson the form of each, or the kind of substance of which it is composed, is not to be the subject of observation, but rather the position of the bodies.

Take the slate and lay it *on* the table and let the children describe where you have put it; then lay the paper *on* the slate and the glass *on* the paper.

Point out that the paper is *under* the glass and *over* (or *on*) the slate, or that the paper lies *between* the glass and the slate. Similarly describe the position of the other bodies.

Then set the tumbler *on* the slate and put the chalk *in* the tumbler. Let the children describe the position of each body, and explain why the chalk is said to be *in* rather than *on* the tumbler—because it is enclosed or surrounded by the tumbler. Let a child place a lead pencil *in* the tumbler, then *on* the tumbler, and note the difference in position. Similarly place a piece of paper *on* the book and *in* the book.

Invert the tumbler *on* the slate and *over* the chalk, and again get an explanation as to the cause of difference in the terms used.

Set the tumbler, chalk, and book together in the middle of the table; move them away *from* each other, *towards* each other, and one *round* the other.

Set the three bodies apart again and show how the description may vary according to the object which serves

as the point of reference: e.g. the middle object in moving *towards* one moves *from* the other, while an end object might at the same time be moving towards *both* of the others.

Hold the book *before* (or *in front* of), *behind* (or *at the back* of), and *at the side* of your body. Point out that, while 'before' and 'behind' are fairly definite, 'at the side' might mean one of two very different positions, and ask the children to describe clearly which side, e.g. *right-hand* side. Then let them see that it is necessary to state *whose* right-hand side is intended.

Again, show the importance of the point of reference by giving a child in the middle of the class a slate to hold 'before,' at 'right-hand side,' &c., of himself, and let neighbouring children also describe the position of the same slate with regard to themselves.

Then let the children be asked to place the slate in various positions with reference to the table or desk—e.g. *under*, *over*, *on*, take it *from*, or bring it *to*, &c.—and illustrate the more certain understanding of such descriptions than of others, such as to place it *before* (or *in front* of) the table or at *the right-hand side* of the table.

Many other illustrations involving this observation and description of the position of bodies will readily occur to the teacher.

[In a somewhat similar manner the position of events in *time* might be illustrated, as some event happens *before* or *after* another, or something occurs *at* or *after* nine o'clock, or *after* nine and *before* ten, *after*noon, *in* the morning, &c.]

LESSON VII.

POSITION ON A SURFACE.

OBJECTS REQUIRED—*Blackboard and chalk; slate; sheets of foolscap paper; lead pencil; string; long ruler (for blackboard).*

ANALYSIS OF LESSON.

Distinguish corners of blackboard and name marked one.

Child point out (or mark) specified corner of a slate held up.

Distinguish edges of board and mark one specified.

Middle point of any edge, and means of testing it.

Exp.—*Measure by string to adjacent corners.*
Estimate middle point of edge of paper sheet and test by folding.
Child lay book in middle of one side of table and measure.

Draw diagonals on board—meaning of point of intersection being termed middle point of board.

Exp.—*Measure to corners and middle points of sides.*
Lay book in middle of table, &c.

Points in similar positions on different surfaces.

Exp.—*Mark point on board, and child mark point in similar position on slate.*

Assistance of fixed lines in determining position.

Exp—*Draw diagonals and lines from middle points of sides on blackboard and slate.*
Mark three points on board and let children copy on slate.

NOTES.

Subject of Lesson.—The last lesson was on the position of one body with reference to another; this is on the observation and description of the position of a point on a surface—the surface of bodies similar to the sheets previously examined.

The blackboard is a sheet of wood (or slate) similar to the sheets studied in preceding lessons, but it is not the nature of the substance that we have now to observe, but how to describe the position of some point or mark on the board.

Make a mark with chalk in one 'corner,' and let the children describe where you have made it. Let them point out the other corners, make marks in those also, and note the number.

Clean out the marks and ask a child to make a mark in one corner. Point out that you might have wished the mark to be made in one particular corner, and get them to describe the corners as 'upper right-hand corner,' &c. Exercise the children in pointing out specified corners on the board and on a slate held up before them.

Next mark a point near the middle of one edge of the board and let them describe its position; and in the same way as before lead them to describe the various edges as 'upper,' 'lower,' 'right-hand,' and 'left-hand,' and let them point out or mark any particular one specified.

Next direct attention to the position of a chalk mark placed in estimated middle point of one edge. Let them explain the meaning of 'the middle point,' and test it by measuring with string the distance of the point from adjacent corners. Let a child mark the middle point on

one edge of a sheet of paper and test its accuracy by folding the paper. Let another lay a book in the middle of one edge (side) of the table and test by measurement.

Again clean the board and rule the diagonals. Note the point of intersection, and let them describe it as being in the middle of the board. Lead them to see that the middle point of the board should be at equal distances from opposite points on the edges, and test this by measuring with the string from that point to the corners and to the middle points of opposite sides. Let a child lay a book in the middle of the table, and stand in the middle of the floor.

Once more clean the board and mark any point on it; then ask a child to mark a point in a similar position on a slate. Draw the diagonals on the board, and also lines joining the middle points of opposite sides, and do the same on the slate. Mark three signs, + ○ ✱, in various positions on the board, and let children mark similar signs in corresponding positions on the slate; pointing out the assistance afforded by the lines in determining the correct positions.

[This lesson might with advantage be repeated, letting each child have his own slate and follow the teacher by marking his own slate as required.]

LESSON VIII.

MEASUREMENT OF LENGTH.

OBJECTS REQUIRED—*Slate, pencil, and rule marked in inches (for each child if possible); piece of string; wooden lath one inch long.*

ANALYSIS OF LESSON.

Distance of point on edge of board from corners.

Exp.—*Measure with string and tie knots to mark lengths. Child mark corresponding point on opposite edge by measurement with string.*

Distance of point on board from each corner, measured in same way.

Distance measured by means of rod one inch long.

Exp.—*Mark points, showing inches.*

Advantage of marked series of such lengths on strip—*tape measure.*

Measurement of distances with tape measure.

Measurement with foot rule of distances greater than its own length.

Exp.—*Measure length of slate, table, &c.*

Fixing position of body by two measurements.

Exp.—*Child lay chalk at given distances from two adjacent edges of table.*

Equality of divisions on rule and tape measure, and necessity for same.

Exp.—*Children rule on their slates lines of given lengths, and mark point in given position.*

NOTES.

Subject of Lesson.—The position of one body with reference to another, or the position of a point on a surface, may be more definitely ascertained and described by means of measurement; and this measurement is best performed by the aid of accurately divided instruments, which show series of lengths formed by the repetition of a fixed unit.

Mark a point on one edge of the board, nearer one end than the other. Let children try to describe its position, so as to understand the difficulty of doing so exactly. Measure with piece of string the distance of the point from one corner of the board, and make a knot in the string there; similarly with its distance from the other corner. Rub out the mark and let a child mark a point on the opposite edge of the board in a corresponding position, finding the exact place by means of the knotted string.

Mark some other point on the board and measure from it to each corner, knotting the string for each distance. Point out how confusing it becomes to have these various lengths so marked and how difficult to keep them distinct.

Next take a piece of wooden lath one inch long and measure two distances, by finding how many times the piece may be laid down, marking with chalk the various points to which it extends. Show a tape measure with similar successive distances—inches—marked on it, and explain its convenience.

Then use the tape measure to measure the distance of a point from the corners, and illustrate the advantage of the fixed divisions over arbitrary knots. Show that the divisions are equal by measuring the same length with different parts of the measure.

Exercise the children in measuring various distances: e.g. distance between two dots marked on board, length of sides of slate, distance from window to floor, &c.

Then repeat some of the measurements with a foot rule (not using smaller divisions than inches), showing how to use the rule to measure distances greater than its own length: e.g. measure length of one side of table or blackboard.

Let a child lay a piece of chalk on the table one foot distant from one end and an equal distance from one side, by estimation; measure the distances as a test, and then lay it accurately in position by measurement.

Compare the rule and the tape measure together, to show that the divisions agree; and explain the necessity for the maker to have one correct rule to take his measurements from, and for his rule to agree exactly with the rules used by other makers and by people generally.

Then set the children to rule lines of given lengths on their slates, and to rule short lines with breaks of a given length. Also practise them in marking a point on their slates in a given position according to measurement either from another point or from two adjacent edges of their slates.

LESSON IX.

MEASUREMENT OF CAPACITY.

OBJECTS REQUIRED—*Sand (sufficient to fill large cup at least); jug of water; basin; tumbler (holding half a pint); glass bottle (holding about half a pint); table spoon; small cup; large cup; foot rule.*

ANALYSIS OF LESSON.

Exp.—*Pour heap of sand on to paper, and let child measure it with rule.*
Measure also tumbler of water: diameter, depth.

Difficulty of stating quantity by such measurement.

Exp.—*Flatten heap of sand and measure again.*

Common expressions—'much,' 'a great deal,' &c.—are vague.

Measurement by some unit—spoonful, &c.

Exps.—*Measure sand in spoonfuls into small cup and express its capacity.*
Find capacity of large cup as compared with smaller; also in spoonfuls.
Repeat experiments with water; explain any difference in numbers.

Half-pint as fixed measure (like inch as fixed length).

Exps.—*Measure half-pints of water into basin to find capacity.*
Estimate quantity of water in bottle, and test.

NOTES.

Subject of Lesson.—The measurement of capacity, like the measurement of length, is based on the comparison of one quantity with another taken as a unit, such as a spoonful, cupful, or half-pint; and the capacity of a vessel is described by stating the number of unit quantities it will contain.

Pour out a quantity of sand on to paper, and pour some water into a tumbler, and say that it is the object of the lesson to measure the quantity of such substances as sand and water. Let a child measure across the sand and water with the foot rule in various directions (including the depth), and let the children state if that clearly describes the *quantity* of the substance. Show that it does not by spreading out the heap of sand and repeating the measurement.

Then let them explain whether the usual expressions—'a great deal,' 'a little,' 'not much,' &c.—would clearly describe the quantity. They may thus be led to see the necessity for some other method of measurement.

With a tablespoon take up a spoonful of sand—let them express the quantity as a spoonful (remind them of the common expression 'spoonful of sugar,' &c.)—and put it into the small cup. Continue putting in sand to fill the cup, counting the number of spoonfuls, and write the number on the board.

Then let them describe how they would measure the capacity of the larger cup, so as to compare it with the smaller, e.g. by filling the large cup with sand in the same way as the smaller one.

Pour the small cupful into the larger cup, fill the small one again, and pour into the larger until the

latter is full. Then express the capacity of the larger compared with the smaller cup (e.g. say it holds about one and a half times as much), and also let the children state how many spoonfuls it holds.

Repeat the experiments with water instead of sand, and let the children explain why the number of spoonfuls required to fill the small cup is not the same as when sand was the material, noting how the water stands just level with the edges of the spoon, while the sand may be heaped up above those edges.

Then explain that, as spoons and cups vary much, some more fixed measure must be agreed upon, if we wish to measure accurately. A glass tumbler, holding half a pint, may be taken as being made to contain a fixed measure, and when filled with water may be spoken of as holding half a pint of water. Pour that water into a basin; again fill the tumbler, and pour the water again into the basin, leading the children to speak of the quantity in the basin as two half-pints or one pint. Fill the basin in this way, and state its capacity in half-pints and in pints.

A bottle full of water may then be taken, and the children required to estimate its capacity as being half a pint, or more or less than half a pint. Let them suggest how to test it—e.g. by pouring the water into the tumbler.

LESSON X.

A BALL.

OBJECTS REQUIRED—*A ball of solid indiarubber, another of smooth wood; two slates; an apple (or orange).*

ANALYSIS OF LESSON.

Uses of ball in play: *to roll, throw, &c.*

All parts of surface alike.

Same form when viewed from any position.

Exp.—*Draw outline on board.*

Rests equally well on any part and rolls easily in any direction.

Exp.—*Roll on table in various directions with finger.*

Rolls down inclined surface.

Exp.—*Hold slate horizontal with ball resting on it; incline slate.*

One ball not lie on another.

Exp.—*Lay one slate on another; try to rest one ball on another.*

Ball comfortably held in hand, owing to absence of edges and corners.

Many natural objects somewhat like ball in shape.

Note flattening or hollow in apple or orange; body stands more steadily on those parts.

Exps.—*Try to roll apple resting there, and show it resting on inclined slate.*
Rest ball on apple.

NOTES.

Subject of Lesson.—This lesson introduces the class to the study of solid forms, and to certain properties dependent on the form and independent of the nature of the substance. The sphere being the simplest solid, in that its surface is uniform, is first examined, a ball being taken as a familiar representation.

Speak first of the various uses of the ball in play—rolling, throwing, catching, &c.

Next call attention to the shape, comparing it with the sheets previously examined. Note that there are no corners or edges, and it is difficult to tell one part from another, or to describe where a mark has to be made.

Hold the ball in various positions, and note that it has the same appearance in every position—drawing the outline on the board. The ball lies equally well on every part of its surface: there is no special top or bottom. It can stand alone, and in one position as readily as in another.

It can be rolled easily on the table by the finger, and in one direction as easily as in another.

It will lie at rest on a level (horizontal) surface, as on a table, or slate carefully held; but moves so easily that it rolls downwards if the surface (e.g. the slate) is inclined. A child might be set to hold the slate level with the ball lying on it, and then told to incline the slate so that the ball may roll in any required direction.

One slate can rest steadily on another in certain positions, but one ball cannot rest on another, and the children might be led to connect this fact with the ease with which the ball rolls in any direction.

Owing to the absence of edges and corners, the ball is comfortably held or caught in the hand, and has no sharp parts to hurt the hand even if tightly pressed.

Let the children name objects very similar to the ball in shape—marbles, some stones, apples, oranges, &c.

Taking an apple or orange as an illustration, note its difference from the ball in certain flattened or hollowed parts; and show that those parts are different by the fruit being able to stand more steadily on them —not rolling so easily by the finger or on an inclined slate—and by the possibility of resting a ball on the fruit at that part.

LESSON XI.

MARBLES.

OBJECTS REQUIRED—*A number (twenty to thirty) of stone marbles; ball; small tumbler; vessel of water.*

ANALYSIS OF LESSON.

Compare marble with ball.

Substance of marble—stone.

In what, then, different from ordinary stones?

Exp.—*Lay heap of marbles on table.*

Why do they move apart?

Exp.—*Lay one marble on three others.*

Note unsteadiness of arrangement, and explain cause.

Note form of hand when holding marbles.

Exp.—*Let child hold several marbles in one (open) hand.*
Lay other marbles on those in the hand.

Marbles are stored in receptacles with sides.

Quantity of marbles ascertained by counting, or possibly by measurement (cupful, &c.)

Marbles in vessel do not occupy the whole space.

Exp.—*Pour water among a large number of marbles in glass vessel.*

NOTES.

Subject of Lesson.—We examine in this lesson a number of bodies, each similar in form to the others and to the ball, and note particularly the characters which result from the association together of several objects, rather than from the form of each individual.

Commence first by noting the form of any one of the marbles, and let the children compare it to the ball treated of in the last lesson. Illustrate the rolling of the marble by the finger and on an inclined slate, &c.

Let the children state whether the marble is made of similar substance to the ball, and explain that many marbles are simply pieces of stone. Let them give a reason why children are not satisfied to play with ordinary stones.

Then take several marbles in the hand, and lay them down on the table, noting how they probably roll apart from each other. Point out also that, though you may lay them down in a heap, they do not readily remain so when the hand is removed. Let a child try to rest one marble on the others, showing, for example, that one may be made to rest on three others close together. (Lead them to compare the hollow space between the three marbles with the hollow on the apple or orange on which a ball was rested.) But this arrangement, it may be pointed out, is very unsteady, since any cause which makes the lower marbles roll—e.g. a shake of the table—is sufficient to upset them. The cause of this is seen to be due entirely to the shape of the marbles. Evidently it would not do to build our walls of pieces of a similar shape.

Ask some child to hold several marbles in his open hand, and point out the manner in which he holds his

hand—like a small cup—and let the children explain the reason for this shape. Show also that if the marbles are thus kept from rolling apart others may readily lie on them.

This will lead to the reason for keeping marbles in some vessel which has sides to support them and prevent them from rolling apart—e.g. a box, cup, bag (pocket), &c.

Ask the children how they would ascertain whether one quantity of marbles contained more than another; and explain that counting would be tedious if the quantities were very large—if, for example, it were required to compare two large boxes or bags full. Let them suggest some other method, such as measuring them in cupfuls (as was done with the sand and water in a previous lesson).

Put some marbles in a small tumbler, and notice how they rest against the sides of the vessel and are kept from rolling apart. Enquire if the vessel would be quite full if the marbles came level with the top, or if they quite fill the part of the vessel containing them. Lead the children to observe the spaces between the marbles, and pour some water into the tumbler, noting how it fills up the spaces among the marbles.

LESSON XII.

PEAS.

OBJECTS REQUIRED—*Half a pint of dry peas in tumbler; a few peas previously soaked in water.*

ANALYSIS OF LESSON.

Revise chief facts learned as to behaviour of number of marbles.

Exp.—*Put handful of peas on table.*

Inference as to shape from seeing them roll.

Note irregular form (flattened sides) of peas.

Effects of these flattened faces on movement of peas.

Exps.—*Roll pea with finger.*
Rest on inclined slate.
Pour peas on table to make heap.

Why is the heap better than with marbles?

Rounded form still permits very ready movement.

Exp.—*Press on heap.*

Source of peas.

Peas soaked in water swell and become rounder.

Exp.—*Show soaked peas.*

Explanation of shrinking by drying.

A pea has a definite structure: two parts inside a covering skin.

Measurement of quantity—pints &c.

NOTES.

Subject of Lesson.—A quantity of peas consists of a number of bodies more or less rounded in shape, and therefore behaves somewhat like the collection of marbles in the last lesson; but, as the form is less regular, there are differences resulting from this cause. In other important respects, apart from shape, peas differ from marbles.

Remind the children first of the subject of the preceding lesson, and question them briefly about the principal facts observed as to the behaviour of the marbles.

Lay a handful of peas on the table, and let the children state whether they behave in any way like the marbles—e.g. rolling apart. Then, if they roll in this way, we can infer something as to their shape; let them give the inference, and examine one pea to see how far the inference is correct.

But is the pea just like a small marble? Let some child point out the irregular shape—perhaps certain flat parts. Let them tell you what advantage there would be in laying a pea on one of these flat faces, and show them that it does not roll so readily on an inclined surface or by the finger.

Pour out some peas from the tumbler, or from folded paper, on to the table (or slate), to form a heap. Let the children again contrast them with marbles under the same conditions, and explain the possibility of a heap as due to the less regular form. Make a drawing on the board showing the heap composed of peas above supported by others below.

Press the heap to show how little force is needed to disturb the arrangement; and let the children explain

how it is possible to press the upper peas lower down by reason of the lower ones moving apart.

The marbles were pieces of stone made into shape. What is the source of the peas? Briefly describe the peas as seeds obtained from plants, and let the children describe how fresh green peas differ from the ones shown, viz. in being more rounded and smoother.

Show them some peas soaked in water, and let them describe the changes which have taken place. Help them to infer that the water soaking into the peas has swollen them and filled them out, and that if laid out of the water to dry they would again shrink up and become of less regular form. The fresh green peas, then, are wet and full of water, while those used in the lesson have been dried. (If necessary, apples may be referred to as shrinking in the same way when kept and allowed to dry.)

Break a soaked pea, to show the two pieces of which it is composed and the enclosing skin, and contrast peas, which are thus made up, with marbles which are similar all through.

Refer again to the measurement of the quantity of marbles, and let the children suggest the best method of measuring the quantity of peas for sale, &c. Remind them of the fixed measure used in a previous lesson—the half-pint. The peas, like the marbles, do not absolutely take up all the space, but that cannot be avoided and is not taken into account.

[As an illustration of the peas being seeds some might be left in water for a few days, till they commenced to grow.]

LESSON XIII.

GRAINS OF WHEAT.

OBJECTS REQUIRED—*Grains of wheat (about half a pint); glass tumbler; glass of water.* [*Wheat, sprouting on plate or tumbler, should be shown either at the lesson or soon afterwards.*]

ANALYSIS OF LESSON.

Exp.—*Pour out wheat on table.*

Note formation of heap.

Comparison of heap of wheat with heap of peas in former lesson, and peas with marbles.

Heap best formed of least regularly shaped pieces.

Shape of grains of wheat.

Nature of wheat—'grains'—seeds.

Seeds will grow into plants, which again bear seeds.

Grains in heap not fixed, and are easily displaced.

Exps.—*Press on heap to flatten it.*
Put finger into heap.

Spaces exist between grains of wheat. What demonstration?

Exp.—*Put some wheat into tumbler and pour in a little water.*

Brown coating of grain encloses white material (flour).

Exp.—*Crush grain to show flour.*

Uses of flour.

NOTES.

Subject of Lesson.—A quantity of grains of wheat are so far like peas that they are seeds of uniform shape; but that shape is further removed from the regular spherical form than in the case of peas. While they agree with peas in certain respects, owing to their similar origin and nature, in other respects they are different.

Pour out a heap of grains of wheat on to the table, and compare it with the heap of peas previously seen. Call attention to the manner in which the pieces roll down the sides of the heap, and how it consequently spreads out at the bottom.

Try and make it into a fairly high heap, and let the children say from observation whether they think a heap is formed with these pieces any better than with peas. Let them say why peas form a better heap than marbles, and lead them to the conclusion that the more regular the spherical form the less readily do the pieces stand in a heap.

Then examine one piece to note its form—the rounded sides and narrow ends, the furrow or groove down one side, &c.—and make a drawing on the board to illustrate its outline. Show that the others are similar in shape. Does the form, then, explain why a heap is more readily formed of these pieces than of peas?

What are these pieces? Explain that they are a kind of corn—*grains* of *wheat* they are called—that they are seeds which we eat for food.

But what are seeds? The peas were called seeds. Some children will, perhaps, explain that seeds, if set, will grow into plants, bearing leaves and flowers and

more seeds. Speak briefly of the conditions under which seeds grow, and set aside for a few days some grains of wheat in a tumbler containing a little water, to grow. The peas would grow up into a plant on which more peas would grow, the wheat into a plant on which more grains of wheat would grow.

Returning, then, to the heap, ask what it is made up of, and what keeps the upper grains in their places. Press the heap, as was done with the peas, to show how easily the grains are displaced.

Put the finger in the heap, and lead the children to understand how the grains separate to allow the finger to enter. Remind them of the spaces between the bodies in the case of marbles, and how the existence of the spaces was demonstrated. Let the children suggest how the existence of spaces between the grains of wheat could be shown. Put some wheat in a tumbler and pour in water.

The colour of the outer surface of the grain should be noted, and then a grain crushed with a stone or knife-handle, the children being asked to state what further information they obtain from the crushed grain. Tell them that the white powder from inside the grain forms an important food (flour), and speak of some forms in which it is eaten. The outer brown part of the grain is also frequently eaten and is present in 'brown bread.'

LESSON XIV.

SAND.

OBJECTS REQUIRED—*Clean sand (about half a pint); paper; piece of stone (quartz or flint best) of irregular shape; old piece of slate, to be scratched; book; slate; glass of water; [magnifying glass, if possible].*

ANALYSIS OF LESSON.

Exp.—*Pour out sand in heap on paper.*

Note formation of heap.

Nature of substance—small pieces in very large number.

Exps.—*Moisten finger and take up several grains.*
Count number of grains on finger and compare with heap.

Each 'grain' is a small broken piece of stone.

Exps.—*Examine large grain by a magnifying glass, if possible.*
Show specimen of broken stone.

Hardness of grains.

Exps.—*Press grain on hand; rub on old slate.*

Heap yields readily, showing small support to the grains.

Exps.—*Lay book on heap, and put finger in amongst grains.*

Small spaces are present between grains, into which water can penetrate.

Exp.—*Make hollow in heap on slate and pour in water.*

Wet sand more easily retains moulded shape, water between grains keeping them together.

Exp.—*Mould wet sand in various shapes.*

NOTES.

Subject of Lesson.—This lesson carries one step further the examination of collections of small bodies, the grains of sand being smaller in size and more irregular in shape than the other substances examined.

Pour out some sand on paper to form a heap, making the heap as high as possible. Let the children describe what has been previously pointed out about such heaps—how most of the pieces roll down the sides and spread out at the bottom, so that the bottom of the heap is much wider than the top.

Let them enumerate the objects formed into heaps in previous lessons, and state whether the present substance is one of those named, or what it is. Moisten the finger and lay on the sand so that some grains adhere to it; let several children examine the grains, and let some one count approximately the number of those on the finger. Point out what a very large number there must be in the heap and what a long time it would take to count them; and let the children explain why if there are so many pieces the heap is so small.

Selecting one fairly large grain, let a child hold it in his hand and try to describe it. Tell the children it is called a 'grain' of sand. Help them to realise the grains as small pieces of stone; tell them they are really broken fragments of stone. Show them a broken piece of stone and ask if all broken stones are similar in size and shape. Point out that this is an important difference between sand and the peas, wheat and marbles, the marbles being pieces of stone cut or worked into a regular size and shape.

Then, to confirm your statements that the sand grains are really small stones, point out that stones are usually

hard bodies, and let the children describe some way of testing whether these grains are hard: e.g. press them between finger and thumb, rub them on the palm of the hand, rub them on a piece of old slate and note the scratches. Ask the children which of them have seen a heap of stones, and point out that the heap of sand may be regarded as a heap of small stones.

Rest a book on the top of the sand heap and note the effect, viz. that it flattens the heap. Let the children, from the information obtained in the previous lessons, explain that the flattening is due to the ease with which the grains are moved, owing to the small amount of support they have.

Put the finger into the sand and let the children explain again how the finger is able to make its way so readily into the sand. Illustrate these points by referring to the impression made by the foot when walking on sand, and the ease with which holes may be dug in sand.

Make a hole in the middle of a heap of sand lying on a slate, to form a cup, and pour in some water. Let the children observe that the water disappears, and explain what becomes of it, and how it is able to make its way through the sand.

Show that the wet sand can be made into special shapes, and retains its form more readily than the sand when dry. Explain this as due to the water between the grains holding them together.

LESSON XV.

COMPARISON OF MARBLES, PEAS, WHEAT, AND SAND.

OBJECTS REQUIRED—*Marbles on plate; peas, wheat, and sand in heaps on pieces of paper; tumbler; small bottle.*

ANALYSIS OF LESSON.

Recognition of substances and order in which studied.

Association of substances in classes: stones and seeds.

'Grains.'

Method of storing such substances (in bags, &c.), and reason.

Differences in power of forming heaps.

Spaces between parts—proof; different sizes of these spaces.

Exp.—*Shake sand in among marbles in tumbler.*

Reason for loose sand settling into smaller space when shaken.

Exp.—*Shake bottle full of loose sand.*

Measurement of quantities of such bodies.

Uses of these substances.

NOTES.

Subject of Lesson.—Direct comparison of the small objects studied in the last four lessons with a view to recapitulate the main points of agreement and difference which have been observed.

Let the children first recognise the four substances lying in small heaps on the table; let them mention the order in which they were studied and suggest a reason for taking them in that particular order—order of size and regularity of shape.

Then let them say which of the substances are most nearly alike in their nature: e.g. marbles and sand are pieces of stone, peas and wheat are seeds and will grow. Let them state which pieces are spoken of as 'grains.'

Ask them how a quantity of any one of these substances could best be kept together or stored—e.g. in bags, bottles, or boxes—and let them give their reasons, viz. they must be held together by something like the sides of the bags, &c.

Point to the heaps, and let the children again explain why the marbles do not readily form a heap and why the other substances do so more readily, and some more readily than others. Speak of large heaps (hills) of sand on the sea shore, &c.

Then remind them of the spaces found to exist between the bodies forming the heap; let them state in which case these spaces are largest and which smallest, and explain how they would prove their existence to others. Vary the demonstration by putting sand into a tumbler partly filled with marbles and gently shaking down the sand.

Put some sand lightly into a small bottle to fill it; knock or shake the bottle and note that the space

occupied is less, and let the children suggest an explanation, viz. that the grains have been shaken nearer together. If the grains are nearer together let them state what else must follow, viz. that the spaces must be smaller.

Speak of the method of measuring quantities of such substances by capacity—handful, cupful, shovelful, pint, &c.

If any time remains the uses of the various substances might be discussed, and the reason why marbles, wheat, and peas have to be bought—while sand costs very little or may be had for nothing—explained.

LESSON XVI.

SANDSTONE.

OBJECTS REQUIRED—*Sand (in heap on table); cup or glass containing moist sand; plate (or slate); piece of coarse sandstone; hammer to break sandstone if necessary; glass of water.*

ANALYSIS OF LESSON.

Recapitulate principal facts learnt about sand.

Difference between moist and dry sand, and cause.

Exps.—*Turn out moist sand on plate.*
Rest slate or book on moist sand.
Let child crush the heap.

The sandstone is composed of similar grains—meaning of name.

Sandstone needs no support to keep its grains together, &c.

Exp.—*Roll sandstone on table and hold it up by one corner.*

Something holds grains together more firmly than water.

Exps.—*Rest several books or slates on sandstone.*
Let child try to crush it.

Requires some considerable force to separate the grains.

Exp.—*Break off piece and crush to sand.*

Use of sandstone for building.

Source of sandstone.

Porosity of the stone—proof.

Exp.—*Show drops of water sinking into stone.*

NOTES.

Subject of Lesson.—Attention having been directed in preceding lessons to collections of small solid bodies, a mass consisting of obviously similar pieces cohering together is now studied, partly with a view to noting the differences due to this coherence and partly to introduce the subject of the structure of solid bodies so far as that may easily be ascertained.

Commence with a short conversation about sand, what it really is and where it is commonly found, e.g. by the sea shore and often forming beds or layers in the ground. Pour out some sand on to a piece of paper to make a heap.

Next moisten some sand in a cup and ask the children what difference it makes to have the sand wet, letting them tell you of the moulding of wet sand in a previous lesson. Turn out the sand from the cup on to a plate or slate, and note how much more readily it stands in a mass; question the children to see if they remember why it does so, viz. because the grains are held together by the water between them. Remind them of children building castles, &c., with moist sand on the sea shore.

Show them that such a mass of moist sand will bear a slight pressure, such as the weight of a small book laid on it. Let the children state what would be the result of applying a greater pressure, and let some child press his hand on the mass so as to crush it.

Then show them the coarse sandstone; let several children examine it, to observe that it is composed of a large number of grains of sand. Give them the name 'sandstone' and let them explain the origin of that name.

Lay the sandstone on the table and point to its lying

steadily and the grains keeping together without the necessity for its being enclosed in a box or bag. Roll it about on the table and take it up by one corner; and let the children explain why the grains do not separate, viz. because something holds them firmly together.

Let a child feel it, to note that it is not wet. It is not water, therefore, which holds the grains together, and besides they seem more firmly held than were the grains of the wet sand. Let the children suggest how this last statement may be proved: e.g. rest a much heavier book or books on the mass, and let a child try to crush the sandstone with his hand.

(What it is which fastens the grains together they must learn when they are older.)

Break off a small piece with the fingers or with a hammer, crush it to form sand, and let several children examine the grains and compare them with those visible in the sandstone.

Speak next of the use of sandstone for building, blocks of it being laid one on another to form walls for houses, &c. Lead them to understand how the fact of the grains being so firmly held together enables each block to bear the weight of those above and to retain its particular shape. Explain that those blocks are obtained by breaking off masses from rocks forming hills, or exposed in quarries in various parts of the country.

Then, lastly, suggest the question whether the grains in the sandstone are quite close together or whether there are spaces (or pores) in the mass, as was found to be the case with the heap of sand. Let them suggest some means by which this could be ascertained. Pour a little water on the stone and notice how it sinks into the mass in the same manner as they saw it sink into sand in a previous lesson. A few words might be said about the water soon drying out of the stone again if left for a time.

LESSON XVII.

A CUBE.

OBJECTS REQUIRED—*A large wooden cube (such as is used for model drawing); several small wooden cubes (Kindergarten cubes); a wooden ball; piece of sandstone; a slate; scissors; sheet of paper as large as face of cube; string.*

ANALYSIS OF LESSON.

Regular shape of cube compared with piece of sandstone.

Differences between ball and cube.

Exps.—*Lay ball in several positions on level table.*
Try to set cube on one of its edges or corners.
Roll ball with finger and push cube.
Set ball and cube on slightly inclined slate.

Number of faces of cube.

Number actually seen at once.

Enumeration of faces.

Equality of all the faces.

Exp.—*Cut paper equal to one face and lay on others in succession.*

Faces are in pairs of parallels.

Exp.—*Hold hands parallel in three positions for cube faces.*

Let children, without seeing, state number of corners.

Count number, and note similarity.

Number of edges.

Edges all equal in length.

Exp.—*Child to measure one edge with string and compare with others.*

Give name 'cube.'

Advantages of parallel flat faces of cube.

Exp.—*Build column of cubes.*

Edges and corners inconvenient when cube held tightly in hand.

NOTES.

Subject of Lesson.—The cube, as a solid of regular form, is studied apart from the material of which it is composed, and compared with the ball to show how the difference of form leads to a difference in its properties and powers. The characteristic features of the cube are also observed.

Point to the sandstone used in the last lesson as a solid block of no regular shape, but which would need to be shaped before several pieces could be properly built together. Then point to a large-sized cube of wood as a solid piece that has been cut to a very regular shape; which shape, however, is very different from that of the ball previously studied.

Let the children suggest a number of differences between the two forms—e.g. the ball will lie equally well on any part of its surface, but the cube will only lie on one of its flat faces, &c. (Let them try to make it stand on one corner or one edge.) The ball will readily roll over and over if pushed by the finger, but the cube simply slides along on one face, and is not easily rolled over. The ball will not lie on a slightly inclined surface (such as a slate held in a slanting position), but rolls down it; while the cube will remain at rest if the surface is only slightly inclined, and slides, not rolls, if the inclination is greater.

Let the children count the number of these flat faces as the cube lies on the table, and let each of several children state how many of such faces he can actually see. Lead them to describe the faces as the cube stands before them, as top, bottom, right-hand, left-hand, back, or front face.

Show them that all the faces are equal and similar.

Cut a piece of paper equal in size to one of them, and show that it fits all; and, therefore, unless one is specially marked it cannot be distinguished.

Point out that the faces are in pairs parallel to each other, and let the children hold their hands parallel and in positions corresponding to the three pairs of faces.

Set all the cubes out of sight, and let the children state how many corners (or points) the cube has, to see if they have observed, or have a sufficiently accurate mental picture of the cube to reckon up the number without looking at the object. Then set the large cube on the table before them, and again let them state the number. Count the number while the cube is held up: point out that all are alike, and let several children state how many they can actually see at one time.

Then let the children observe the edges of the cube, and count the number while the cube stands in one position; and let a child measure several of the edges with a piece of string, to prove that all are of equal length.

Tell them that bodies shaped like this, with six equal faces, eight similar corners, and twelve equal edges, are called *cubes*, whatever their size.

Illustrate the advantage of the parallel flat faces by building a column of several cubes. Let the children compare this with the building of a wall, and understand the advantage of the flattened faces of the bricks. Let them state whether the bricks are cubes, and give their reasons.

Let a child hold a small cube in one closed hand and the ball in another, and state which is more comfortably held, especially if the hand is tightly closed. Let the children explain what causes the inconvenience in the case of the cube, and thus see again that the ball has no corners or edges, all its parts being alike.

LESSON XVIII.

DIVISION OF CUBE AND SPHERE.

OBJECTS REQUIRED—*Wooden ball and cube; ball and cube of soft clay (or soap), to cut; large knife (or piece of thin string) to cut the clay.*

ANALYSIS OF LESSON.

Let children compare ball and cube and illustrate their statements.

Division of cube into *halves*.

Exp.—*Cut clay cube through centre points of opposite edges.*

Comparison of pieces with each other and original cube.

Division of one half into *quarters*; calculate total number.

Exp.—*Cut one half into two pieces.*

Division of one quarter into eighths; note that they are cubes, and calculate total number.

Exps.—*Cut one quarter into two cubes.*
Arrange half, quarter, and eighth in order and name first two.

Division of sphere—*hemisphere*.

Exps.—*Cut into hemispheres.*
Lay one hemisphere on flat face, other on curved, and note difference.
Trace outline of flat face on board.

Division into quarters.

Exps.—*Cut one hemisphere into two equal parts.*
Trace outline of one flat face of the quarter.

Let children put pieces together to reconstruct original forms.

NOTES.

Subject of Lesson.—The cube and sphere, being typical forms, are again compared with each other, and the pieces obtained by simple primary division of the bodies are compared with each other and with the original body. The lesson will thus illustrate not only form, but, in a simple manner, fractional parts.

Let the children again compare the ball and cube, as in the last lesson, leaving them to suggest the points of difference and the means of illustrating these.

Then take the cube of clay (or of soap), and with a knife or piece of string cut it down through the middle points of two opposite edges. Lead the children to compare the two pieces as to size, and to speak of them as *halves*. Let them state whether the pieces are cubes, and give their reason for saying they are not. Show that they have the same number of faces, corners, and edges as a cube, and ask how many of the original faces, corners, and edges of the cube each contains unaltered.

Then cut one of the pieces again across, and compare the two parts with each other, to show they are equal and similar, but not cubes. Let the children state how many such pieces would be obtained from the original cube, and give the name *quarters*.

Once more cut one of these pieces to form two small cubes; let the children recognise them as such, and calculate the number which could be obtained from the original cube.

Then let some child arrange the pieces of the cube in order—viz. half, quarter, and eighth—and exercise the children in stating of each what part of the cube it is, or how many similar pieces the original cube contained.

Proceed in a similar way to cut the ball of clay (which should be carefully worked into shape) into two equal parts. Compare these with the original shape, and notice the flat side with a circular outline; give the name *hemisphere*. Let the children see one hemisphere lying steadily on its flat face, and compare it with the other rocking on its rounded surface; noting that the latter does not roll over and over as a ball would do, but only rocks from side to side.

Cut one hemisphere into two equal parts through the middle point, let the children state how many such parts could be derived from the whole ball or sphere, and speak of each as a quarter. Examine the faces, to see whether flat or curved; lay one flat face on the blackboard and trace its outline.

Then let a child arrange the pieces of the ball on the table in the same way as those of the cube, and exercise them in using the terms half and quarter.

Let one child put the pieces of the ball together again, and another the pieces of the cube in their original positions to form the complete solid.

LESSON XIX.

BALL OF WOOL.

OBJECTS REQUIRED—*Ball of white wool (or worsted); specimen of raw or unspun wool; piece of string; small piece of knitting.*

ANALYSIS OF LESSON.

Description of ball.

Differences between this and balls of wood and clay previously used.

Exps.—*Press it between thumb and finger.*
Drop it on table, &c.

Ball is made up of long piece of thread or yarn.

Exp.— *Unwind part of ball and let yarn form heap.*

Advantage of carefully wound ball.

Exp.—*Tangle a piece of string and let child try to pull it out straight.*

The yarn is composed of very fine threads (fibres) twisted together.

Exp.—*Give pieces to several children and let them untwist them and lay fibres together in little heap.*

Advantage of twisting a number of loose fibres together.

Exps.—*Pull apart the loose fibres in the heap.*
Twist several together and show increased strength.

Source of wool.

Exp.—*Pull out several fibres of raw wool, and twist.*

Uses of wool in making scarves, stockings, &c.

NOTES.

Subject of Lesson.—This lesson carries the children a step further in the direction of observing the structure of bodies. The ball is obviously made up of a long thread or string, and this again is readily ascertained to be composed of numerous smaller threads or fibres.

Speak first of the object as a ball, and let the children mention some of the methods of using balls in play. What can be done with this ball which was done with the ball used in a recent lesson? Is it the ball used in the previous lesson, and if not how can they distinguish it? Let them state some differences between the two: e.g. this one is softer, and can be pressed readily together by the finger and thumb; it is lighter, and makes less noise when dropped, &c.

Then tell them that the object of the lesson is to find out something as to what the ball is made of, and remind them how the sandstone was found to be made of grains. Let several children examine the ball, and state if they can see how the ball has been made. Partly unwind the ball, to show that it is made of a long piece of thread or string; and let the unwound thread lie in a heap on the table. Let the children explain the advantage of having the thread wound into a ball rather than lying in a heap; and refer them to pieces of tangled string, showing them such a piece and letting some child try to get the string out straight.

Then let some children examine small pieces of the thread and observe how they are made up; and untwist several, to show the very fine threads or fibres. Make a small heap of these loose fibres on the table, and show how much easier it is to pull them apart than it is to break the thread or yarn made of a number twisted

together. Twist some of them together, to show how much stronger they are in that condition.

The ball then may be described as made of a very large number of small threads or fibres, first twisted together to make a kind of string or yarn, and then the latter rolled up into a ball.

Let the children describe where such fine threads come from. Show them some unspun wool; pull out a few threads and twist together to make yarn.

Let them suggest some articles made of wool, as scarves, stockings, &c. Show them some knitted wool, and point out that it is made of similar small fibres, first twisted together to make yarn, and then pieces of yarn looped and fastened together, instead of being wound into a ball.

A short conversation about the use of the wool to the sheep, and its use, when manufactured, to ourselves, might follow.

LESSON XX.

STRUCTURE OF BODIES.

OBJECTS REQUIRED—*Ball of white wool; one or more peas which have been soaked in water; an orange; ball of soft clay; a common stone marble.*

ANALYSIS OF LESSON.

The bodies agree in having rounded form; will roll, &c.

Bodies arranged according as the form is natural or artificial.

Object of lesson to ascertain structure of bodies.

Structure of ball of wool.

Exp.—*Unwind some wool and untwist to show fibres.*

Structure of pea: covering skin, and two pieces.

Exp.—*Remove skin of pea and separate the lobes.*

Structure of orange: skin and several segments.

Exps.—*Remove skin of orange and note flattening and marks of divisions.*
Divide orange into halves and quarters.
Divide one quarter into segments and calculate total number.

Name other natural bodies enclosed in skin (grape, &c.)

Shrinking and wrinkling of pea (and orange) on drying.

Ball of clay has no apparent structure and may be broken in any direction into irregular pieces.

Exp.—*Break clay into several irregular pieces.*

Enumerate varieties of structure noted.

NOTES.

Subject of Lesson.—This lesson is intended to bring together some facts which have been observed in previous lessons as to the structure of bodies very similar in external form; and also to afford an opportunity of direct comparison between the various bodies of rounded form previously examined.

Lay side by side balls of clay and worsted, an orange, a soft pea, and a marble, and let the children suggest the feature they have in common—viz. that they are rounded in form. Also let them suggest some property due to that form—e.g. that they will roll, that they will not readily form a heap or allow of being built into a column.

Let them also state which of the bodies are in their natural form, and which of them have been artificially shaped, and arrange them on the table accordingly.

Remind them that some of these bodies have been previously examined and found to be made up of easily recognised pieces; and state that the chief thing to be done in this lesson is to compare them with each other as to the kind of pieces of which they are made, where that can be readily ascertained.

Start with the ball of wool, and question them on the facts as to its structure learnt in the last lesson; unwind a little of it, and untwist it to again show the fibres. Let them examine the other bodies, so as to be able to state whether any of them are made up in the same way as the ball of wool.

Next take the pea and question them to see if they have remembered what was learnt of its structure. Break it carefully, to show that it is composed of two pieces contained in a covering or skin. Let them

suggest the name hemisphere as describing approximately the form of those pieces.

Then ask if any of the other balls are like the pea in having an outer skin enclosing pieces. When they have suggested the orange, carefully remove the peel from it, and let them describe the shape of the fruit and state where and how it differs from a true sphere. Carefully divide it into two parts as nearly equal as possible, and let the children give the terms halves and hemispheres. Divide one of them again approximately into two equal parts, and get the name quarter. Then break up one of the quarters into sections, and calculate the number in the whole orange. Let the children point out on one of the sections which face was part of the original surface before division, and give their reason for the statement.

Let them give examples of other natura bodies enclosed in a skin somewhat similar to the orange—e.g. grape, lemon, &c.—and state whether they resemble the orange in being composed of a number of segments. Point out that a large quantity of watery juice is contained in the orange; question them to see if they remember about the shrinking up of peas as they get dry, and let them infer that the same thing would take place as the oranges dried.

The ball of clay and the marble may then be examined, to show that they are not obviously made up of recognisable pieces, nor have they an external covering. Show that the clay may be broken readily into pieces of any shape, and as easily in one direction as in another. The same is true of the marble, only there is more difficulty in breaking it.

Let the children, in conclusion, enumerate what they have learnt as to the structure of bodies—viz. that

sandstone is made up of small pieces called grains, wool of small threads, a pea of two pieces held together by a kind of skin, an orange of many pieces enclosed in a different kind of skin, while a ball of clay does not appear to be made up of any pieces that can easily be recognised or that are arranged in any particular way.

LESSON XXI.

COLOUR.

OBJECTS REQUIRED—*Ball of white wool; similar ball of black wool; skeins of coloured wool (light and dark shades of red; light and dark shades of blue; yellow; green; duplicate skeins of two of the shades); white blotting-paper; red ink; black ink.*

ANALYSIS OF LESSON.

Structure of ball of wool (white).

Structure of other (black) ball similar; difference only in colour.

Exp.—*Unwind and untwist some black wool.*

Natural colour of wool.

Artificial colouring—'dyeing.'

Exps.—*Dip white blotting-paper in black ink.*
Similarly colour piece of white wool.
Repeat above experiments with red ink.

Name colours of wools shown.

Exp.—*Let child select colour asked for, and match colour of specimen given.*

Shades of one colour—light and dark.

Exp.—*Let child select examples of same colour but different shade.*

Colour of objects (books, fire, &c.) in room compared with wools.

Colours of common natural objects.

Pleasing and displeasing combination of colours.

Exp.—*Twist together wools in various combinations.*

NOTES.

Subject of Lesson.—The colour of a body is often one of its important properties, and affords a means for recognising the body. This property, which has not so far received much attention in these lessons, is now shortly studied, and attention directed to the manner in which the natural colours of bodies may often be artificially changed.

Again introduce the ball of white wool, and briefly question the children on the structure of the ball and the source of the wool. Then show a similar ball, but of black wool. Let the children state what substance it is, and give their reasons. Unwind part of it, and untwist to show that the structure is just the same as in the other case. What, then, is it that is different? Some of them who have seen sheep can say which of the two is more like the natural colour.

Show them some white blotting-paper, and let them state its colour; then dip it in black ink, and let them explain how the colour has been changed. Speak of this as 'dyeing,' and dip a piece of white wool in ink to colour it. Explain that this black colour might perhaps be washed out, and that people have found out ways of colouring the wool so that the colour is not lost when the wool is washed.

Similarly dye some blotting-paper and some white wool red in red ink, to show that different colours may be obtained by the use of different substances.

Having thus shown that the natural colour of wool may be artificially changed, the remainder of the lesson may be spent in examining some small skeins of various coloured wools, letting the children name the various colours. Have two skeins of one or two colours alike,

and let the children choose one (if present) to match one given. Show them how to lay the pieces side by side in a good light, in order to compare the colours more satisfactorily.

Taking out those which may be generally spoken of as red, let them describe how they differ—e.g. one is darker or lighter than the other. Then let them find two others which are similar in colour but of different shades.

Let them point out coloured objects in the room, name the colour, and show which of the coloured wools most nearly resembles the object in colour.

Let them also suggest natural objects having colours somewhat similar to one shown—e.g. name bodies which are red, blue, &c.

Then explain that frequently the different colours are used together, and that some colours are pleasant to see together, while others are not pleasant. Show them various combinations of colours—e.g. lay red and green or yellow and green side by side, or twist them together—and let the children learn to appreciate those that harmonise.

LESSON XXII.

FLOWERS.

OBJECTS REQUIRED—*Specimens of coloured wools (as used in last lesson); several kinds of common flowers (of fair size and simple form: e. g. buttercup, tulip, primrose, wild rose, &c.); one plant with leaves and flowers; second kind of leaf.*

ANALYSIS OF LESSON.

Colours of specimens of wool.

Short general conversation on flowers.

Name colour of flower shown.

Exp.—*Select wool nearest in colour to flower.*

Difference in flowers—shape and colour.

Leaves—different in shape and shade of colour.

Exp.—*Compare colours of two leaves and draw outline form.*

Flowers conspicuous and attractive to persons and insects.

Object of insect in visiting flowers.

Structure of flower a subject of interesting study.

Most conspicuous part of flower composed of coloured, leaf-like pieces.

Exps.—*Separate petals of simple-formed flower and draw outline of one, and diagram of arrangement in the flower.*
Do same with another kind of flower.

Other parts of flower important and worth study.

NOTES.

Subject of Lesson.—In connection with the subject of colour, treated of in the last lesson, no natural objects are so striking as flowers, and these are therefore now briefly considered, chiefly as to their colour, but also as to the general form of the brightly coloured parts.

Commence by showing the children the coloured wools used in the last lesson, letting them give the names of the colours, and distinguish between the light and dark shades.

Then take some brightly coloured flower, and spend some little time in general conversation about flowers—e.g. as to where they grow, at what time of the year they are most abundant or most scarce, why people are so fond of flowers, &c.

Let them describe the general colour of the flower shown, and select the piece of wool most nearly like it. Note the different shades of colour in various parts of the flower.

After a question as to whether all flowers are like the one shown, and, if not, in what respects they differ (e.g. colour and shape), show two or three other flowers, and have the colours named and the specimen of wool most nearly of the same colour selected.

Then call attention to the green flattened pieces growing on the plants along with the flowers, and get the name for them—Leaves. Let the children state from previous observation whether all leaves are alike, and, if not, in what respects they differ. Show two or more different leaves; make simple outline sketch of each on the board to emphasise the difference in form, and lay them side by side to show the difference in colour.

Then ask them which part of the plant is prettiest

which most conspicuous and most readily noticed, and which part most children would like to gather and carry home. See if they have observed that plants have other visitors in the shape of bees and other insects, and suggest that these bright-coloured flowers serve to let the insects know where the plants are. A few words might be said as to the object of insects in visiting flowers.

Take a large or simple flower (e.g. a buttercup, primrose, or tulip), and point out to the children that, just as they were able, by looking carefully, to find out something about the manner in which the ball of wool, orange, &c., was made up, so it is possible to learn something as to the various pieces of which a flower is made up.

[As this subject alone would furnish material for several interesting lessons, the teacher can only in this lesson just indicate the manner in which the subject might be followed out, in the hope of leading the children to observe such points for themselves, and take an opportunity of returning to the subject on some future occasion.]

Show that the main part of the flower is composed of flat, leaf-like pieces; separate these and count the number. Draw an outline sketch of one on a large scale on the blackboard, and also a diagram of the position of the various parts as seen on looking down at the flower. Briefly note that there are other parts of the flower, differing in size, shape, and colour from each other, but all very important and worth studying when the children are older.

Take the coloured leaves (petals) from a second kind of flower to illustrate the difference in form, and, lastly, show the children how to press the flower between

sheets of blotting-paper in a book—either the flower as a whole or the petals separately—so as to preserve the specimen.

[The teacher should carefully separate the parts of one or two common flowers, and dry and mount them in position for illustrating such lessons as this, or for simple drawing copies.]

LESSON XXIII.

SMELL.

OBJECTS REQUIRED—*Turpentine (or paraffin oil) in bottle; piece of camphor; scented flower (e.g. rose or wallflower); glass of water.*

ANALYSIS OF LESSON.

Flowers interesting for colour, form, and *smell.*

Exp.—*Examine flower having distinct scent.*

'Scents,' or 'perfumes,' obtained from flowers.

Some liquids, like water in appearance, are distinguished by characteristic smell.

Exp.—*Pour little turpentine or paraffin oil on duster or slate, and let child smell.*

Some bodies that are invisible have a strong smell, and may thus be recognised.

Exp.—*Let coal gas escape into room for a few seconds; hold duster or hand against it, and let children smell it.*

Some solid bodies are distinguished by their characteristic smell.

Exp.—*Illustrate smell of camphor.*

Some bodies have no smell. Name some.

Exp.—*Let child test water, chalk, glass, &c.*

The nose is the part of the body which detects the smell.

Exp.—*Illustrate manner in which child puts camphor or turpentine, &c., near its nose.*

Means of avoiding unpleasant or strong smell

Use of sense of smell (*a*) to ourselves, (*b*) to animals.

NOTES.

Subject of Lesson.—Our power or sense of smell enables us to learn something about bodies, and to distinguish particular substances which may even be invisible. This sense is of use to man and animals in various ways.

Show the flower provided as an illustration, and lead the children in conversation to ascribe our interest in it to its form, colour, and *smell*. Remind them that some flowers have a much stronger or sweeter smell than others, and their presence in a garden or room may be first made known to us by the smell.

Explain that people endeavour to extract from flowers the substance which causes the smell, calling such substances 'scents' or 'perfumes,' and using them to scent handkerchiefs, &c.

Turpentine (or paraffin oil) is similar to water in its general appearance, but may be distinguished at once by its characteristic smell. Pour a little on a duster or slate and let the children smell it. Let them also smell the turpentine in the bottle, and then at some water in a glass.

The gas which comes from the pipes and which we cannot see has a characteristic smell, and we usually know of its presence in the air by its smell. Let a little gas escape into the air; hold a duster or the hand against the escaping gas and note the smell remaining on the article. Speak of the danger of explosion with an escape of gas and the value of the sense of smell in giving us knowledge of the presence of this kind of gas.

Some solid bodies also have a characteristic smell and may be readily distinguished by the smell. Camphor is very similar in general appearance to sugar and several

other substances, but has a very characteristic smell. Let several children smell the piece of camphor.

Point out that all bodies have not a smell, and let the children name some such bodies: e.g. water, chalk, glass. Let some children test these bodies to prove that they have no smell.

Then call attention to the manner in which people try to observe the smell or scent of bodies: e.g. children in smelling the piece of camphor or the turpentine hold the substance near the nose, and if the smell is not very strong sniff the air into the nose. Draw the conclusion that our power of smell lies in the nose. This is confirmed also by our holding the nose to avoid as much as possible a very strong or unpleasant smell.

The sense of smell is useful to us in making known the presence of substances which might sometimes be injurious—e.g. escaping gas, bad or spoiled air in a 'close' room, smouldering or burning clothes, wood, &c. It is still more useful to animals, which find their food, track their prey, or learn of the approach of their enemies by the sense of smell. Describe a dog following the track of his master or of a fox by the scent.

LESSON XXIV.

TASTE.

OBJECTS REQUIRED—*Two glasses of water; spoon; salt; white sugar; vinegar; glass rod (or clean pencil).*

ANALYSIS OF LESSON.

Bodies may be recognised or distinguished by their smell.

Bodies may be alike in having no smell, yet evidently different bodies.

Exp.—*Show and test sugar, salt, and water without naming them.*

Recognise sugar and salt by taste.

Exp.—*Teacher first, then children, taste sugar and salt.*

Warn children against tasting unknown substances.

Children name other bodies having distinct taste, and describe taste.

Exp.—*Child taste drop of vinegar and describe taste.*

Examples of bodies with *sweet*, *sour*, *salt*, and *bitter* taste.

Some bodies, like water, have no distinct taste—tasteless.

Exp.—*Child taste water and state whether sour, &c.*

Substances which cannot be seen may sometimes be recognised by taste

Exps.—*Dissolve salt in water and taste a drop; ditto with sugar.*

Natural examples of water containing dissolved salt or sugar.

Organ and use of sense of taste.

NOTES.

Subject of Lesson.—Taste is another means by which we are often able to distinguish one substance from another, or ascertain that one substance is in that respect similar to another.

Remind the children of the subject of their last lesson, how by means of the nose we are able to learn something about many bodies which we describe as their *smell*, and so are often able to recognise a substance even though we may not be able to see it.

Show them the sugar, salt, and water, without naming them, and let some children observe whether they have any smell. As they are all alike without smell we could not thus distinguish between them, and yet we can see they are not alike. We might, perhaps, find out without seeing them that they are not alike if we put them into our mouths.

Put a little of the sugar into your own mouth and then ask several children to do the same. Ask the children the object of putting the substance in the mouth, viz. to *taste* it. [Warn them against tasting unknown substances, which might perhaps be poisonous; and say that you yourself know what these substances are, but that you wish them to find out for themselves.]

Let the children describe the taste, and name other substances having a sweet taste—e.g. honey, treacle, ripe fruits, &c.

Then deal with the salt in a similar manner, letting the children after tasting give the name of the substance.

Ask them next to name some other substances which have a taste, and let them try to describe the taste. Let them taste a drop of the vinegar (take out a drop on a glass

rod), try to describe that kind of taste, and mention other substances with a similar (sour) taste. Lead them to speak of some substances as bitter—e.g. bitter oranges, the rind of lemons, quinine, &c.

Reminding them that they have described sweet, salt, sour, and bitter tastes, let a child drink a little water and state what it observes about the taste. It is neither sweet, salt, sour, nor bitter, nor has any distinct taste, and is said to be tasteless. Let them name some other tasteless substance—e.g. glass.

Put a spoonful of salt in a tumbler of water and stir till it is all dissolved. Point out that as far as can be seen the salt has gone; ask them where it is, and how we might find out that it is there. Let some child taste a drop of the water, to note the taste of the salt. We may thus learn by taste what we could neither find out by seeing or smelling. Remind them that the water of the sea is salt, and yet, like the water in the glass, it may be perfectly clear.

In a similar way dissolve some sugar in the other glass of water and let a child taste some. Let the children say what it is that tastes, the water or the sugar. Refer to the juice of ripe fruits, which consists nearly all of water, but as it is sweet we learn that it also contains sugar, though we cannot see any.

Then let the children state with which part of the body we taste, and briefly explain to them the use and advantage of this sense in connection with our food.

LESSON XXV.

TOUCH.

OBJECTS REQUIRED—*Piece of chalk; glass marble (or tumbler); sandstone; slate; smooth (writing) paper; rough (brown) paper; smooth and rough pieces of wood; bag containing indiarubber ball and small wooden cube; moist clay.*

ANALYSIS OF LESSON.

By *smelling* and *tasting* we learn about things; so by *touching* them.

Exp.—*Child touch chalk, glass, and sandstone, and describe difference noticed.*

Sense of touch very general, but best exercised by tips of fingers.

Exps.—*Let children touch slate by cheek, back of hand, and finger-tips.*
Compare smooth and rough paper, and wood.

Facts learned by means of touch.

Exps.—*Let child hold clay in hand and describe facts learnt by touch.*
Ascertain differences between clay and wood to touch.
Let child put hand in bag containing india-rubber ball and cube, and state all facts ascertained by touch.

By touch we learn whether body is hot or cold—water, &c.

Some facts about bodies cannot be ascertained by touch.

Use of touch in dark and to blind.

NOTES.

Subject of Lesson.—Another very important sense is that of touch, by means of which we can ascertain several facts about a body, such as whether it is rough or smooth, hot or cold, &c. Some parts of our body are able to exercise this sense much better than others.

Refer to *smell* and *taste* as means of learning something about substances, and state that we can also learn much by *touching* them. Call some child to the table, and after he has recognised and named the chalk, glass, and sandstone let him touch the substances. Then after touching them let him state whether he notices any difference to the touch, and try to describe the difference: e.g. glass is smooth and hard, sandstone is rough, chalk is not so smooth as glass nor so rough as sandstone.

Then call attention to the manner in which he proceeded to touch them, letting the children state with what part of the body—the finger-tips—it is best to touch things if we wish to learn something about them. Let some of the children touch a slate with the cheek, the back of the hand, and the tips of the fingers, to observe that they can feel with each of these parts; and let them then state which part they would use to find out best whether a body was rough or smooth. Let them again state the parts of the body used in smelling and tasting, and point out that there is only part of the body for each of those senses, and no choice as in the case of touch.

In a similar way let the children note the difference to the touch of smooth and rough paper, rough and planed wood, &c.

Then let a child take a piece of moist clay in his

hand and describe what he observes when he touches it with his fingers—e.g. that it is moist, cold, soft, perhaps sticky, &c. Next let him touch a piece of wood and compare it with clay as far as the sense of touch is concerned.

Take a bag containing an indiarubber ball and a wooden cube, and let a child put his hand in the bag and state what he can find out about what is in the bag. Help him, if necessary, by questions to state the number, shape, relative size, whether smooth or rough, and if he can guess the material let him give some reason for his statement.

Speak of persons sometimes putting their hand or finger in water to find out something about it, and let the children state what it is they can thus learn. Refer to pieces of coal or iron recently taken from a fire and perhaps quite black, but which, on touching them, are found to be still hot.

Having thus shown how much may be learnt by touch, let the children state what could not be learnt about a body by touch—e.g. its taste, smell, whether we could see through it, &c. Remind them of the use of touch to us when in the dark, in feeling our way, &c., and of its use to the blind.

LESSON XXVI.

SIGHT.

OBJECTS REQUIRED—*Book (with coloured back); sheet of glass; glass tumbler; small wooden cube; pocket knife (table knife, or other object not familiarly known to children).*

ANALYSIS OF LESSON.

Enumerate senses previously considered and give examples of their use.

Another means of ascertaining presence of child, position of picture, &c.

Description of book from sight, and comparison with facts ascertainable by touch.

Exp.—*Hold up book before class.*

Bodies very far away may often be seen, and something learned of them by sight—moon and stars, sun.

Points of resemblance, and differences between bodies may often be seen.

Exp.—*Hold up sheet of glass and glass tumbler for description.*

Facts observed by sight may be remembered and recalled.

Exps.—*Hold up glass sheet and wooden cube for short time; then lay out of sight while children state differences observed.*

Hold up less familiar object for half-minute, then lay out of sight and get full description.

The eye is the part by which we see. Proofs.

We can only see when there is light.

NOTES.

Subject of Lesson.—The most useful, perhaps, of all our senses is that of sight, by which we can learn something about bodies, though at a distance from us, and can ascertain points of resemblance or of difference. We can also remember and recall the facts we learn in this manner. This sense is exercised through the eyes and is possible only in the presence of light.

Commence by letting the children state the means already described of learning about things—viz. smell, taste, and touch—and let them give examples of the exercise of each sense.

Then state that we have another and even better way of finding out some things, and let them describe how you could ascertain whether a particular child was present, whether his hands were clean, whether he was sitting up straight, &c. Lead them also by questions to state what you could learn about a map or picture on the wall at some distance by looking at it—e.g. whether it was hanging straight, was still, &c.

Hold up a book and let them state what they can tell you about it after merely looking at it—its colour, size, shape, position, &c. Let them also state which of those facts they could have learnt by touching the book instead of seeing it, and which facts they could not have so learnt.

Remind them that at night when we look up to the sky we see some things we could not touch; let them name the things (moon and stars) you refer to, and state why you cannot touch them. Let them state what they know about those things that are so far away—e.g. that they are very numerous, appear small and bright,

and some brighter than others, and that the moon changes its shape.

Then refer to the sun, seen in the daytime, and let them state what they know of it, and whether and how they could know when it was shining on them if they were not able to see it.

Show them a sheet of glass and a glass tumbler, and let them tell you as many things as possible in which they see the two substances are alike—e.g. both are bright-looking, colourless, transparent, &c.—and then what difference they see.

Next show them the glass sheet and a small wooden cube for a few seconds, and tell them to look well at them. Remove the two objects from the view of the children and let them tell you as many differences between the two bodies as possible. Point out that they can not only see the differences but can also remember what they have seen.

Then carry a step further the illustration of this power of remembering and recalling the impressions obtained by sight by showing them some less familiar object (e.g. a pocket knife with one blade partly open, or a table knife, or a bottle containing some liquid), and after holding it before them for half a minute put it out of their sight and let them tell you as much as possible about it. When they have stated all they remember to have noticed suggest certain further points that might have been observed—e.g. in which position and direction it was held, with which hand, whether the blade was longer than the handle, whether the bottle had a cork or a glass stopper, &c.

Lastly let them state the part of the body by means of which we see, and the means of proving this—e.g. by covering up the eyes or turning away the head. Also

point out that sometimes we cannot see though our eyes are open, and let them state when that is; and thus explain that we can only see when there is light from the sun or from a candle, lamp, &c., to shine on the bodies at which we look.

[*Note.*—The exercise of describing various bodies after a very short view of them is a very valuable training in quickness and accuracy of perception, and should be repeated on several occasions.]

LESSON XXVII.

HEARING.

OBJECTS REQUIRED—*Indiarubber ball; wooden ball; ball of soft clay; old book; piece of old slate; glass tumbler (or saucer).*

ANALYSIS OF LESSON.

Enumeration of means of obtaining information about things.

How do they know time for school, or to stop play?

Examples of information obtained by hearing—horse in street, &c.

Hum of bee or wasp usually first indication of its presence.

What does scratching of pencil on slate show?

Nature of sound may enable us to distinguish between bodies, &c.

Exps.—*Drop indiarubber, wood, or clay ball on floor, out of sight.*
Drop wood and clay balls at same time.
Drop wooden ball successively on floor, slate, or book, out of sight.

Nature of sound sometimes indicates condition of body, e.g. whether cracked.

Exp.—*Strike gently tumbler or saucer on hand by lead pencil.*

Movement of wind made known by sound.

Sounds may be agreeable or disagreeable. Examples.

Part of body concerned in hearing. Proof.

NOTES.

Subject of Lesson.—The fifth and last of the senses —hearing—is also useful as a means of obtaining information about many bodies.

Again remind the children of the use of sight, touch, smell, and taste as means of obtaining information about things, and state that we have still one more such means.

Let them say how they are reminded that it is time to come to school, or time to come in from play, viz. by hearing the sound of a bell or whistle.

Let them give other examples of information obtained by hearing, and help them by questions if necessary—e.g. how they know when a person is speaking, when the water tap is turned on, when a horse is coming on the road or a band playing, &c.

Remind them of the way in which we usually first get to know of the presence of a bee or wasp or a blue-bottle fly, all of them small creatures not readily seen.

When a pencil makes an unpleasant scratching noise on the slate, what does the teacher know? Either that there is a very hard piece in the pencil or it is being held in the wrong way.

By the nature of the sound we can sometimes find out what body makes it. Show them several balls on the table—indiarubber, wood, clay, &c. Let them close their eyes while you roll one over the edge of the table on to the floor, and state from the character of the noise which one has fallen. Repeat this two or three times, and then let the soft clay and the wood fall at the same time. Let the children try to describe the difference they observe between the sounds.

Then lay on the floor a piece of old slate and a book,

and drop the wooden ball sometimes on the floor and sometimes on the slate or book, letting the children say, without looking, on what the ball fell.

Hold a glass or saucer on the hand and ring it by gently striking it with the finger or a lead pencil. Let the children describe the sound, and explain if they can why persons often try glasses and other vessels in this manner. Explain that it does not ring properly if cracked; so that from the sound we may learn whether or not there is a crack in the vessel.

Sitting in our houses we sometimes hear a noise outside or in the chimney. What is that? On going out nothing is to be seen except perhaps the trees or the dust moving.

Point out that sounds may be agreeable or disagreeable, and let the children give examples—e.g. shouting, singing out of tune, birds singing, &c.

Lastly let them state with what part of the body we hear, and give some reason for their statement—e.g. stopping the ears sometimes to avoid loud or unpleasant sound, holding bodies making somewhat faint sound near the ear (such as shaking a nut near the ear).

LESSON XXVIII.

THE SENSES.

OBJECTS REQUIRED—*Clean piece of turnip (with outside rind removed) on plate; clean piece of soap on plate; knife; tumbler of water; bottle of turpentine (or paraffin oil or ammonia.)*

ANALYSIS OF LESSON.

Enumeration of methods of obtaining information about things. Examples.

The *senses*—names, number, and organs.

Examination of substance, to learn about it.

Exp.—*Let children examine piece of turnip on plate, and write on blackboard statement of facts observed.*

Name of substance examined.

Additional facts ascertained by experiment or trying.

Exps.—*Cut turnip with knife, put piece in water, &c.*

Examination of second substance, e.g. piece of soap.

By which senses do we learn most?

Some senses require substance to be in contact with body, others do not. State which.

Examination of a liquid—paraffin oil, turpentine, &c.

Facts ascertained by senses may be remembered and communicated.

Enumerate several facts about a body (e.g. ice or salt) and let children suggest name of body.

NOTES.

Subject of Lesson.—This lesson is intended to afford an opportunity for recapitulating some of the facts observed in the preceding lessons on the use of the senses, to lead the children to associate the various senses together as means of obtaining full information about a body, and also to some extent to compare the various senses with each other.

Question the children as to the manner in which we are able to learn about things; let them tell you how they would ascertain if milk or sugar had been put in their tea, if a pencil were sharp and smooth, if a sponge or cloth were wet, if milk were sour, if it were raining, &c.

Tell them that these ways of finding out about things are called our *senses*; and let them give the names of the senses, state their number, and the parts of the body concerned in the use of each.

Then say that you wish to find out all you can about a given piece of substance. Take a piece of turnip with the outside cut off, and without mentioning its name let them suggest how you should proceed. Let the children state what they observe of the substance by sight and write down the statements in simple language on the blackboard. Then let a child touch it and note such facts as that it is wet, not very soft, &c.; let another observe the smell and the taste, and write down the statements on the board. Let the children after this examination suggest the name of the substance.

Show them that you might learn still more about it if you tried to do certain things with it—e.g. cut a piece with a knife and notice that it cuts easily and with little noise; put a piece in water and note that it sinks.

Point out that such facts as these can only be found out by trying, or, as it is called, by experiment.

Then in a similar manner examine a piece of soap, omitting the taste, and, as before, write on the blackboard the statements made as the result of observation. Let some child cut a piece and describe what he learns by the cutting; let the piece fall on the table and let them say what the dull sound shows. Let them give the name of the substance, and then say what they have previously observed when soap is left in water, when stirred or rubbed in water, &c.

Ask them by which senses we learn most about bodies, and illustrate the answer by reference to the facts learnt about the soap.

Point out that sometimes we must actually touch the substance with some part of the body, while other senses can be used when the body is at a distance; and let them state which of the senses come under each of these two heads.

Then let the children themselves without help examine some liquid, such as paraffin oil, or turpentine, or ammonia, and state what they ascertain about it and the manner in which they have found it out.

Lastly, remind them that what we learn about bodies we may remember and may tell to other people. Describe to them the facts you may be supposed to have found out about some very common substance (such as ice, coal, salt, &c.), without giving the name of the substance, and let them state what substance it is you are describing.

LESSON XXIX.

WEIGHT.

OBJECTS REQUIRED—*Piece of lead pipe (about six inches long); two sheets of foolscap paper; small book; much larger book; wool (loose); large stone; balls of wool, wood, and indiarubber of about same size; small feather.*

ANALYSIS OF LESSON.

Facts ascertained by touching bodies.

Exps.—*Let children touch lead while held in teacher's hand.*

Let child hold lead in his own hand.

When body supported in the hand something else may be observed.

The weight of a body is observed as we keep it from falling.

Comparison of weights of bodies, and method of statement.

Exp.—*Roll up paper tube similar to lead pipe, and let child hold lead and paper.*

Common expression 'as heavy as lead.'

Relative weights of bodies often judged from their size, e.g. large and small books.

Exps.—*Let child test relative weights of two books.*

Let child try to raise one end of table or large box.

Make heap of wool about equal in size to stone, and compare.

Press wool together to explain cause of small weight.

Weight of body is not altered by pressing it closer if quantity of stuff remains the same.

Exp.—*Sheet of paper open, then crumple into ball.*

Bodies arranged in order of weight.

Exp.—*Child arrange balls in order of weight after testing.*

Common expression 'as light as a feather.'

Exp.—*Child hold feather; let feather and lead fall.*

More accurate method of finding weight of body.

NOTES.

Subject of Lesson.—Another fact to be observed about bodies is their weight; and the weights of different bodies may be compared in a simple way by balancing them in the hands. The weight of a body depends to some extent on its size, but not on size alone.

Show the children the piece of lead pipe (not mentioning its name), remind them of the examination of substances in the last lesson, and let them state what they could find out if allowed to touch the piece of lead. Let some children touch it as you hold it. Then let a child hold the lead in his own hand, and state what other fact he observes, and whether he could have found out that it was heavy by merely touching it as it lay on the table or in your hand.

Ask them what the substance would do if the child let it go; tell him to do so, and then to take it up again; and explain that when he holds it he is really keeping it from falling.

Roll up a piece of writing-paper to form a tube about the same size as the lead pipe, and let a child hold the lead in one hand and the paper in the other, and describe the difference he observes. Ask him what he would say of the lead, and then of the paper. Give the name of the lead, and quote the common expression 'as heavy as lead.'

Then lay two books on the table, one much larger than the other, and let the children first say whether both would have the same weight, or which would be the heavier, and give their reason. Let them say how they would proceed to ascertain if they were right, and let some one hold the books to test the statements.

Let some child try to lift one end of the table or a large box, and explain why it is so difficult to raise.

Take a fairly large stone and make a heap of wool on the table about as large as the stone. Let the children again say whether the wool and the stone have the same weight, and give some reason for their statement. Let them test them and thus see that size alone is not a sufficient guide. Let them, if they can, explain why the heap of wool is so light, viz. because the stuff is so spread out ;—show this by pressing it together.

Ask them if the wool is any heavier when pressed together. Show a sheet of paper opened out and then crumpled together, and lead them to understand that as there is just as much paper as before it is neither heavier nor lighter, but has just the same weight.

Let a child take the balls of indiarubber, wood, and wool in his hand, and then arrange them on the table in order of their weights.

Remind them again of the expression 'as heavy as lead,' and see if they know the corresponding phrase 'as light as a feather.' Show them a small feather ; let a child hold it, then drop it and let them compare the manner in which it falls with that observed when the piece of lead falls.

Question them as to a better way of finding out exactly how heavy a body is, and say that they must learn about weighing bodies in a future lesson.

LESSON XXX.

LEAD AND IRON.

OBJECTS REQUIRED—*Piece of lead pipe; iron pipe of about same size; piece of sheet lead; pocket knife; hammer; flat stone or piece of hard wood to hammer on.* [*The lead and iron pipes may be obtained from a plumber.*]

ANALYSIS OF LESSON.

Fact observed about lead pipe in last lesson; means of learning more about lead.

Exp.—*Show piece of sheet lead and let children name substance.*

How proceed to find out if both it and pipe are of same substance?

Exps.—*Child hold sheet lead in hand to note weight.*
Bend pipe, and let child bend sheet. Note that they both remain bent.

Explain advantage of latter character in use of lead for pipes, roofs, &c.

Exps.—*Stick point of knife into pieces of lead; cut pieces from edge; scrape surface.*
Child mark lead with thumb nail.

How describe substance cut and marked so easily?

Exp.—*Hammer pieces of lead on stone or hard wood and note result.*

Colour of lead on old and on fresh surfaces.

Are the two pieces really of the same substance?

Compare iron pipe (without giving name) with pieces of lead.

Exps.—*Test iron pipe as lead previously tested, but in order suggested by children.*

Colour of iron on old and new surfaces—black or brown rust.

Exp.—*Show key or knife and test to show iron.*

Name iron and compare with lead.

NOTES.

Subject of Lesson.—Some further properties of lead are now to be observed in addition to its great weight, dealt with in the last lesson. Then iron—a somewhat similar substance—is to be compared with the lead in these particulars, and proved to be really a different substance by the difference in its properties.

Show the children the piece of lead pipe used in the previous lesson, and let them state what particular fact was then observed about it. Explain that, as you wished to learn something about the weights of other bodies, you did not ask them last time to notice all they could about the lead; but that in this lesson you do want to find out much more about it, and let them suggest how to proceed.

Show them a piece of sheet lead, and after letting them see that it is not a pipe like the other piece ask them what substance or stuff it is. If they say 'lead,' tell them that you will proceed to examine both pieces together, and ask them to state what they expect to find out in that case, viz. that both substances will be alike in every way you try them.

First let a child hold the sheet lead in his hand, and state whether anything he observes would lead him to think it was lead.

Next bend the pipe and let a child do the same with the sheet; note how they remain bent, and explain that these pipes used for water and gas may easily be bent to fit the walls, and the sheet lead on the roofs similarly bent to the required shape.

Show that the point of a knife or a pin may be stuck into each piece, and that small pieces may readily be cut off from the edges or scraped from the surfaces. Let a

child try to mark and scratch the lead with his thumb nail; and state how he would describe a body that could be marked and cut so easily, viz. that it was soft or not very hard.

Strike each piece near one edge with a hammer while laid on a piece of stone or hard wood, and let children describe how each is marked by the blow; that also shows it is not a very hard substance.

Then ask about the colour; see whether they have observed the bright appearance of the fresh surfaces as compared with the dull colour of the old ones.

Let them then state whether they consider the two pieces are indeed made of the same kind of substance, and give several reasons.

Then show them a piece of iron pipe of about the same size as the piece of lead pipe, but do not mention the name of the substance. The problem is to find out whether this is also made of lead. Let a child hold it in his hand and say whether he thinks it heavy; then let him compare it with lead by holding one in each hand.

Then let the children suggest various methods of testing or trying the iron in the same manner as the lead was tried. Try to bend, cut, and scratch it; hammer it, &c., and each time let the children state whether it behaves as the lead did.

As regards the colour, suggest that perhaps its real colour does not show (as was the case with the old surfaces of the lead), and you cannot easily scrape or cut this substance. Show them a piece of what you think is similar substance (e.g. a knife or key) and let them test it in several ways. Then point out that this latter piece has been well cleaned, and that when clean it does look very much like lead, but that the air makes a

brown or black rust on old pieces of this substance, whilst that on lead is grey.

Is this substance, then, lead? Let them give the name if they can, and mention something else on the table which they think is made of the same substance (e.g. the hammer-head), suggesting also the means by which it could be tested.

LESSON XXXI.

LIGHT AND SHADOW.

OBJECTS REQUIRED—*Burning candle in candlestick; sheet of clean glass; slate; tumbler of clean water; sheet of stout paper; glass lamp chimney.*

ANALYSIS OF LESSON.

Necessity for light; common sources.

Some bodies stop the light which falls on them.

Exps.—*Let children point out source and course of light forming bright patch on floor or wall.*
Hold slate to cause shadow; note that light still falls on slate.

Name *shadow*, and explain cause.

Exps.—*Let light from window fall on child's face, then hold slate between. Let other children and then child himself describe effect.*
Repeat above experiments with light of candle falling on book and on child's face.

Children state general meaning of term *shadow*.

Do all bodies stop light in this way? Children give examples.

Exps.—*Repeat above experiments with sheet of glass in place of slate.*
Hold lamp glass over candle flame.
Roll and hold paper tube similarly.
Hold tumbler of water between light and sheet of white paper.

Bodies which allow light to pass readily are called *transparent*.

Our own shadows, when and where seen, and why position varies?

Exps.—*Carry candle round child and note position of shadow.*
Let child turn round in sunlight.

NOTES.

Subject of Lesson.—Having stated in a previous lesson that we can only see things in the light, we now proceed to consider some of the sources of light, and what occurs when the light falls on the bodies—how it passes almost unchanged through some, while others stop it and produce shadows.

Question the children again about our power of seeing bodies, and let them state under what conditions the bodies cannot be seen, and give the reason. Let them also state where the light comes from at the time of the lesson, and from what sources (e.g. burning candles, oil-lamps, gas flames, burning coal or wood) we get light when we cannot get sunlight.

Explain the object of the lesson to be to take notice of what happens when the light from the sun, candle, &c., comes to (or falls upon) a body. Point to a place on the wall or floor where the sunlight falls, and let the children point out where it comes into the room. Hold a slate in the path of the light, and let them describe and explain the effect produced. Let the children see that the light still falls on the slate, but is stopped from going through the slate to the floor or wall. Let them give the name for the dark patch thus formed, viz. *shadow*.

Repeat the experiment in another form; e.g. let a child stand with his face towards the window or source of light, and then hold up the slate so as to cast a shadow on his face. Let the other children state the effect they observe, and let the child himself also say what difference the slate makes to him, viz. that it hides the window or the light from him.

Then show similar effects with the light from a candle (set somewhere out of the direct sunlight); let it fall on a page of a book, and then hold up the slate between. Also let it shine on a child's face, as before, then interpose the slate.

Then let the children try to state in their own words what a shadow is, and help them afterwards to describe it as a place from which the light is shut out.

The next question is, Do all bodies make shadows when placed in the way of the light? Let the children first answer this from previous experience, and give examples to illustrate their statements. Then hold up a sheet of clean glass, as was done with the slate; let the children observe that there is no shadow, and explain the reason. Also let the child with the glass between the candle or window and himself, explain that the glass does not hide the window. Hold a glass lamp chimney over a burning candle, and note that the light passes readily through the glass.

Let the children give other examples of bodies which do not let the light pass through, and of others that do, illustrating the statements by holding a rolled paper tube over the burning candle, or holding the hand in the sunlight so as to cast a shadow, holding a clear glass of water between the window or candle and a sheet of paper (the paper being held nearly touching the tumbler). Give the name *transparent* to such bodies as readily let the light pass through.

Then refer to the shadow of our own body, which we often see; let the children explain in what position we see it, why the shadow is sometimes in front of us and sometimes behind us or on one side, and why sometimes we see no shadow at all. Illustrate these facts by reference to the shadow of a child, either carrying

the candle round him, or letting him turn round in the sunlight, and pointing out that in the latter case the shadow remains all the time in the same place, though sometimes his face is towards it and at other times his back.

LESSON XXXII.

CHIEF POINTS OF THE COMPASS.

OBJECTS REQUIRED—*Knitting-needle, set in clay or cork so as to stand vertical; pencil; five slates; chalk.*

[NOTE.—*The lesson should, if possible, be given in a room into which the sun is directly shining.*]

ANALYSIS OF LESSON.

Formation of shadows, and position.

Exps.—*Mark position of shadow of window-bar, &c., and note change after some time.*

Set upright rod on slate in sunlight and mark position of shadow.

Change of position of sun during day and accompanying change of shadow.

Exp.—*Note change in shadows previously marked.*

Position of sun at noon—*south.*

Exp.—*Print* S. *on slate and let child hold it against south wall.*

Position of shadow of body with sun in south.

Exp.—*Mark* N. *on slate and let child hold against north wall.*

Relative positions of *east* and *west.*

Exp.—*Stand with face to north, stretch out arms, and mark E. and W. points.*

Times when sun in south, east, and west.

Exps.—*Exercise children in taking marked slates to proper places.*

Mark letters on one slate in proper position lying on table.

Hold up slate with N. *uppermost.*

Intermediate points: N.E., N.W., S.E., S.W.

Exp.—*Let children stand midway between others holding marked slates.*

NOTES.

Subject of Lesson.—The shadow of a body was seen in the last lesson to change its position as the position of the source of light changed. The shadows of fixed objects cast by the sun thus change their places during the day, and either the position of the sun itself or of the shadow of a fixed object at certain times may be used to indicate the chief points of the compass.

Commence by conversation on various sources of light, and on some bodies allowing the light to pass through them while others stop the light and cast shadows. Point out shadows in the room cast by bodies on which the sun is shining, and let the children indicate the body which in each case casts the shadow. Mark the position of some shadow (e.g. of the window bars or window frame) at the commencement of the lesson by laying a pencil or other marker along it. Stick a knitting-needle upright in a piece of clay or cork, set it on a slate in the sunlight, and with a pencil mark the position of the shadow cast on the slate.

Let the children state the general rule as to the position of the shadow cast by a light, and also the change in the position of the shadow of an upright rod as a light (such as a burning candle) is carried round it. Question them to see if they have observed that the sun changes its position with regard to our windows, houses, &c., in the course of the day; letting them point out approximately its position in the morning, evening, and at midday, and then also point out the direction in which it moves. Ask them whether any changes would be noticed in the shadow of a body at various parts of the day, and what changes they would expect to occur. Note whether the position of the shadows previously

marked has changed, and whether the change agrees with the direction in which the sun was said to move during the day.

Point out the position of the sun at noon, and say that is the direction we call *south*. Print a large letter S on a slate with chalk, and let a child hold it, standing in that part of the room pointed out as the direction of the sun at noon.

Then let the children point out the direction of your shadow as you stand in the middle of the room if the sun were shining from the position of the slate; call that direction *north*, print N on a slate, and let a child stand over in the part of the room towards which the shadow would point.

Then standing with your back to the south, stretch out your right arm, call the direction *east*, and mark it as before; and with the left arm point out *west* and mark it also. State that the sun is in the east at six o'clock in the morning and in the west at six o'clock in the evening, and let them point out and also name the direction in which the shadow of the body or a rod would point at those times.

Then let several other children take the slates with the letters, and proceed to the proper parts of the room, and exercise the children in pointing in any direction asked for.

After observing the change in the shadow of the upright needle previously fixed set the needle in the centre of a slate lying on the table, and let the children point out the position of the sun and of the shadow at noon, 6 A.M., and 6 P.M., and mark the four letters N. E. S. W. on the edge of the slate. Then hold the slate with the N. uppermost, to let the children see the relation of the four points to each other.

While the children stand holding up the four marked slates others might be placed half-way between each pair, and each one of these made to name the two points nearest him; and thus the directions north-east, north-west, south-east, and south-west might be briefly explained, and indicated on the one slate previously marked with all the four letters.

[It would be well to put a fixed mark at the position of the shadow of some fixed object at a certain time, and point out on a subsequent day that at the same time the shadow is in the same position; and the use of the sundial for indicating time might be briefly explained.]

LESSON XXXIII.

HEAT.

OBJECTS REQUIRED—*Burning candle in candlestick; tin vessel (closed if possible) containing hot water; clean duster; thermometer (hanging in room).*

ANALYSIS OF LESSON.

Heat as well as light comes from the sun. We *feel* the heat.

A burning candle gives heat as well as light. Proofs.

Exps.—*Hold hand near candle flame in various positions.*
Note melted wax at base of flame.

Heat falling on body usually makes it warmer. Examples.

When light stopped is heat also stopped? Cool shade.

Exp.—*Child hold hand to feel heat of candle, then interpose slate.*

Hottest and coldest walls of house in sunshine.

Examples of bodies giving heat with little light—fire.

Some bodies give out heat but no light. Examples.

Exps.—*Hold hands near tin of hot water to feel heat.*
Touch part of table where tin has stood.

Heat from the water passed *through* the tin to the table.

Exp.—*Set tin of hot water on folded duster in fresh place, and after little time touch the duster and the table under it.*

Some bodies let heat through easily, others do not. Means of holding hot bodies. Examples.

Bodies grow cold on losing heat (unless fresh heat made by burning).

We *touch* bodies to ascertain whether hot or cold.

The thermometer.

NOTES.

Subject of Lesson.—Associated with the light coming from the sun, or burning bodies, is heat; passing from them, as does the light, in all directions. Heat may also come from bodies which do not give light. Bodies which lose heat grow colder, while those to which the heat passes may become warmer. Heat will pass through certain substances better than through others.

Question the children about the position of the sun at noon and at six o'clock; let them state what comes to us from the sun, and remind them that we *feel* the effect when the sun shines on us. What is it that we feel? Let them give other illustrations of the effects of heat coming from the sun (e.g. making wood hot to the touch, melting snow, &c.)

Let the children name other sources of light. Take the case of a burning candle; let them state whether heat comes from it, and give some proofs of it—e.g. feeling it when the hand is held near, the melting of the wax nearest the flame, &c. Let them state in what direction the heat comes from the candle flame, and show, by placing the hand in various positions, that it comes away in all directions.

Explain that when heat comes to a body its general effect is to make it warmer, and let the children give examples.

Remind the children of the manner in which shadows are formed, and suggest the query whether when a body stops the light it also stops the heat. Let them say where they go to be cool on a hot day, viz. in the shade or shadow; and let them say what this proves. Let a child hold his hand so as to feel the heat from the candle, then interpose a slate and let him note the effect.

Explain that heat is stopped along with the light. Ask the children to state from this knowledge which outside wall will be hottest at noon on a sunny day, and which coldest, and give their reasons.

Then let them mention other bodies which give out heat, e.g. the fire; and state whether they give out light also. Point out in this connection that bodies may give out much heat with little light. Ask them in what direction the heat from the fire comes, and what effect it has when it falls on things in the room.

Take a tin containing some hot water and set it on the table. Let some children hold their hands near the sides of the tin and over it; let them also touch the part of the table where the tin has been standing, and then state whether heat comes from the vessel. In this case heat comes without light.

Let them say what was first made hot, viz. the water, then ascertain whether the tin is hot, and ask where the heat came from that made it hot, and then how the heat got to the table, viz. by passing through the tin. Set the tin on a folded duster on another part of the table for a short time; then let a child touch that part to ascertain if heat has passed to the table. What has stopped it, and what has the heat stopped by the duster done to it? Point out that the tin does not seem to stop the heat from passing through, while the duster does. Show them the tin held on the hand with the duster between; let them give other examples of this manner of holding hot bodies, and explain the advantage of so holding them.

Then lead them to consider the change in the body which loses the heat; let them say how the water changes if left standing long on the table, and lead them to understand that the loss of heat is the cause of it

growing cold. Point out that the fire as soon as it stops burning begins to grow cold, and that all hot bodies which are not burning grow cold as they lose heat.

Let them explain how they would proceed to ascertain whether a body is hot or cold—by touching it. Let them give examples of cold and hot bodies. Point to the thermometer in the room as something showing much better than they can tell by touch whether the substance round it is hot or cold, and briefly explain its use in the room as being to show whether the air is hotter or colder at one time than another.

LESSON XXXIV.

COAL.

OBJECTS REQUIRED—*Fair-sized piece of coal; knife; hammer; glass of water; chalk.*

ANALYSIS OF LESSON.

Connection between *heat* and *coal*.

Description of substance. Various tests.

Exps.—*Try to scratch it.*
Put piece in water, &c.

Called *piece*, *block*, or *lump*. Note faces, edges, &c.

Faces are bright or dull; latter soil fingers.

Exps.—*Rub finger on several faces of coal.*
Rub finger against chalk to illustrate cause of blackening.

Coal is readily broken by hammer,—*brittle*; contrast with lead.

Exp.—*Strike coal with hammer to break off piece.*

Compare coal dust—'*slack*'—with sand.

Occurrence of coal in layers or beds—mining.

Phenomena attending burning of coal—smoke, jets of gas, flame, redness, ashes.

NOTES.

Subject of Lesson.—Following up the preceding lesson on heat we next proceed to examine the chief physical characters of the principal substance used as fuel, and some of the phenomena attending its use for that purpose.

Question the children on the subject of heat and its sources; then let them recognise the substance on the table and suggest the connection between it and the subject of the preceding lesson.

Let them say how they would describe the substance to anyone who did not know what it was like, assisting them by such questions as, Is it hard? Can you scratch it with a knife? Has it any smell? If you put a piece in water does it sink or swim? Let the children give the answers to such questions after making the necessary observations.

Ask them to suggest names for the substance—e.g. a *piece* of coal, a *block* of coal, or a *lump* of coal. Let them say whether the block is most like the cube or the ball examined in previous lessons, and point out parts which might be called 'faces,' 'edges,' and 'corners.'

After letting them examine several faces of the coal, let them say if all have the same appearance, and lead them to observe that some faces are brighter than others. Then let them touch two faces, one bright and the other dull, with the finger and note whether there is any difference in the result. The dull face will probably black the finger more than the other. Explain that some of the softer and looser substance sticks to the finger and causes this blackening, and illustrate your meaning by rubbing your finger against a piece of chalk.

Question them as to the effect produced on striking

lead with a hammer; then let them state from previous observation the effect produced on striking coal. Strike the coal with the hammer and break off small pieces. Let the children name other things which readily break when similarly struck, and say that they are described as being *brittle*. Let them describe other ways in which coal might be broken—e.g. dropping a piece or throwing it down, trampling on it, &c. Ask them what it breaks into, and see if they know that 'slack' consists of broken coal. Remind them that sand was spoken of in a former lesson as consisting really of small broken pieces of stone.

Describe briefly how coal occurs buried in the ground in some parts of the country, how it is reached usually by digging down some considerable depth (though in some places it comes up to the surface), and how the miners break off pieces from the bed or layer with their picks. Explain that these men must be paid for their work, and also the men who bring it from the mines to our houses.

Then question the children so as to lead them to describe some of the facts which may be noticed as coal is burnt—how this black substance when lighted grows hot and red, often gives out smoke, sometimes gives out something which we call 'gas' and which rushes out with a noise and takes fire, making a 'blaze' or 'flame;' how the coal gradually decreases in size, something from it all the time passing up the chimney; and how at last only a quantity of 'ashes' are left, which need not be again put on the fire, because they will not burn. (The cinders, or large pieces which have not finished burning, may, of course, be used again.)

LESSON XXXV.

COAL GAS.

OBJECTS REQUIRED—*Small piece of thin paper; clear empty bottle with cork; matches.* [*A gas burner should be readily accessible in the room.*]

ANALYSIS OF LESSON.

Some phenomena attending burning of coal—smoke, gas, flame, &c.

The gas burns and forms the flame above the coal in the grate.

Gas and smoke spread about, and thus differ from pieces of coal.

Gas at gas works passes from heated coal at once into pipes.

Explain (and point out where possible) gas works, gas pipes, gas burners, coal gas.

Substance of common gas pipes. Advantage of lead.

Gas issuing from pipe not visible, but may be *felt*, *heard*, and *smelled*.

Exps.—*Turn on gas for very short time; hold hand over.*
Lay small piece of paper on burner, then turn on gas.
Light the gas.
Collect some in inverted bottle and cork it up.

This gas readily spreads about. Smell of escaping gas.

We can readily move through it, and see through it.

Caution about breathing coal gas, and danger of explosion.

NOTES.

Subject of Lesson.—The subject of coal gas, or the gas (really a mixture of several gases) which is obtained by heating coal, follows naturally after the preceding lesson on coal itself. Although a gas its presence is readily ascertained by its smell and combustible nature, and it may thus be made to prepare the children for a lesson on air, by leading them to conceive of the existence of material substances not apparent to the sight.

Remind the children of some facts stated in the last lesson connected with the burning of coal, especially of the occasional rushes of smoky gas which take fire, and of the volume of smoke formed when fresh coal is put on and which afterwards becomes more or less a mass of flame.

Explain that the substance which thus burns with a bright flame above the coal in the grate is called gas—coal gas—and let them compare the manner in which the smoke rises up into the chimney and spreads itself about—sometimes into the room—with the way in which the coal lies quietly in the fire grate.

Briefly describe how at the gas works the gas from large quantities of hot coal is not allowed to burn, but made to pass at once into pipes, made cleaner, and then passed along other pipes to our houses and schools, to be burnt at the ends of the pipes. Let them explain the terms 'gas works,' 'gas pipes,' 'coal gas,' 'gas-burners,' and, where possible, point out the objects named.

Let the children examine a gas pipe, if possible, and

state of what substance many of the pipes are made, and let them suggest some reason why lead is so useful for the purpose.

Turn the gas on for a moment without lighting it; point out that there is nothing to be seen, and let the children state how you might proceed to recognise its presence—e.g. it might be *felt* coming out against the hand, perhaps be *heard*, and its peculiar *smell* might be observed. Turn it off and lay a small light piece of paper over the end of the burner, then turn it on again and the fragment of paper will be blown away. Let the children state what this proves. Light the gas and point out that it is only near the hole in the pipe that anything burns.

Hold an inverted bottle over the burner while the gas is turned on but not lighted; cork the bottle and set it on the table. Point out again that there is no visible substance in the bottle, and nothing to be felt when the hand is placed against the open mouth, as the gas is not pushing hard out of the bottle, as it was out of the pipes. Let the children state how its presence in the bottle may be known, viz. by the smell.

While the gas was turned on it would probably spread all over the room and most of the children be able to smell it; enquire who did, and point out how different such a substance is from lumps of coal and similar things, which lie still in one place and do not spread about.

Let the children note that though the gas is present all about the room we can see distinctly through it (see if they remember the term 'transparent'), and can also move about in it without feeling it or being stopped by it.

It would be well, in conclusion, to say a few words of caution against playing with coal gas, both from its injurious effects when breathed and also from the danger of explosion when the gas becomes mixed with air and a light is applied to it.

LESSON XXXVI.

THE AIR.

OBJECTS REQUIRED—*Slate; sheet of foolscap paper; tumbler of water; small empty glass bottle.*

ANALYSIS OF LESSON.

The senses—means of recognising certain invisible substances.

Something called air said to be everywhere around us, yet invisible.

Bodies may be moved by *something* (air) which cannot be seen.

Exps.—*Blow against piece of paper, and water in tumbler.*
Fan air with slate against paper and water.

This something may also be *felt* striking against ourselves.

Exps.—*Blow against hand, and fan air against face.*

Similar movements of leaves, dust, &c., caused by *wind*—moving air.

Coal gas spreads about room and is recognised by smell. Air has no taste or smell.

Air does not interfere with movement unless very quick.

Exp.—*Hold sheet of paper by one corner and wave backwards and forwards slowly, then quickly.*

Light and heat pass through air.

'Empty' vessels and spaces are really full of air.

Exp.—*Invert bottle with open mouth in tumbler of water.*

NOTES.

Subject of Lesson.—This lesson is intended to give the children a simple idea of the nature of air, and of the reasons which lead people to say that a substance which they call air is everywhere present, although it cannot be seen, nor is it (like coal gas) apparent by its smell.

Commence with some questions on the senses as the means we have of learning about things, and let the children give examples of things which are not visible but which may be smelled (coal gas), or tasted (sugar in water), or heard (children singing in adjoining room, &c.)

Then remind them that people speak of *the air* as being all about and around us, filling all the things that are said to be empty, that we are constantly breathing it, and yet we can see nothing of it. What reason, then, have people for saying there is such a substance as air?

Blow against a small piece of paper and move it, and blow on the surface of water in a tumbler. Let the children first state what they observe, and then point out that *something* evidently pushes the paper and the water. Blow also against your hand, and let the children do the same with theirs and say whether they feel anything pushing or striking against the hand.

Similarly fan with a slate against the paper and the water, and let the children describe and explain the result; also fan the air against your own face and against the children's faces.

Remind the children that sometimes they see the dust or pieces of paper on the road blown about, and the leaves of the trees moved, yet can see nothing

which moves them; also that they sometimes feel something pressing against themselves and moving their cloaks or coats. Let them state what it is that moves the bodies in these cases, and tell them that this 'wind' is really the air moving about.

Question the children about the coal gas, its manner of spreading about the room, and how they knew of its presence. Let them state if they would have known it was there if it had had no smell. The air has no smell and no taste, so though we breathe it through our mouths and noses we neither taste it nor smell it. Remind them also that the gas in the room did not interfere with their moving about; they did not feel themselves knocking against it; so with the air, it does not hinder us moving about unless we try to go very fast. Move a sheet of paper held by one corner slowly backwards and forwards, and then move it quickly, and note how in the latter case it is hindered and kept back by something in its way.

Let the children say whether light can pass through the air, and give some reason for their statement, also whether it causes a shadow, and whether heat (from the sun or a fire) can pass through it. Remind them of light passing also through glass and heat through tin.

Lastly, show that what we call empty spaces are really full of something. Show the children a small bottle and let them state what is in it; then invert it and plunge it, mouth downwards, in a tumbler of water. Let several children observe that the water has not passed through the open mouth into the bottle, and explain that is because the bottle is quite full of something (air) which keeps the water out of the bottle when it cannot get out itself.

LIST OF APPARATUS

Sheet of glass (about 12″ × 9″)
Piece of board (rough)
Ditto (smooth)
Sheets of tissue paper, brown paper, white blotting paper, and cardboard
Two glass tumblers (half pint)
Glass bottle with flat sides (about 10 ozs.)
Ditto with round sides (6 ozs.)
Glass lamp chimney
Glass rod
Jug (holding about 1½ pint), basin, plate, and two cups (large and small)
Candle (wax) and candlestick
Table spoon (iron)
Scissors
Pocket knife and table knife
Lead pipe (about 8 inches long)
Iron pipe (same length and diameter as lead pipe)
Knitting needle
Small tin can, with lid
Hammer
[Magnifying glass]
[Thermometer, mounted on wood]
Foot rule
Thin wooden lath
Wooden ball (2½ or 3 inches diameter)
Solid india rubber ball (same size as wooden ball)
Large wooden cube
Eight (or more) inch cubes of wood
Balls of white and black wool
Specimen of raw wool
Skeins of coloured wools
Clean (silver) sand, and sandstone
Dried peas
Grains of wheat
Clay
Turpentine
Camphor
Salt
Vinegar
Large glass marble
Twenty-four small stone marbles
Soap
Blackboard, ruler, red ink, and other articles usually present in schoolroom